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Editorial

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Dear Reader,

We are pleased to announce that the International Association for Danube Research (IAD) and the Floodplain Institute Neuburg (Catholic University of Eichstätt-Ingolstadt) will organize the 43th IAD conference focused on "Rivers and Floodplains in the Anthropocene – Upcoming Challenges in the Danube River Basin" from June 9 -11, 2021. Due to the corona pandemic, the event will take place in a virtual format, allowing us to exchange ideas and research results in a safe way. With this opportunity, we invite all IAD members to participate in the General Assembly meeting and elect the new IAD president, the person who will coordinate our activities for the next six years. Please check the conference homepage iad2020.ku.de for the latest updates.

This issue of Danube News presents an overview of the role of hydropower plants and their ecological impacts, the threats posed by new development plans and the lessons learned from the past years.

Long considered as a "clean" energy source due to their low emission of greenhouse gases, hydropower plants proved to have a highly negative impact on river systems. For decades these impacts were not properly prevented/mitigated, and hence, the costs of hydropower energy remained low and attractive to consumers. However, the real price was paid by the aquatic communities, numerous species being brought near extinction, such as the migratory freshwater fish. Without subsidies and with real environmental costs included, the hydroenergy will not remain as attractive anymore as other renewables, such as wind, solar, geothermal, wave energy, become increasingly affordable.

The EU Green Deal, aiming to protect, conserve and enhance EU's natural capital, the EU Biodiversity 2030 Strategy goal to restore 25,000 km of EU rivers to the free-flowing state, the Water Framework Directive, aiming to achieve good ecological status/potential by 2027, and the Habitats Directive, supporting among others habitat restoration for endangered species, provide a key legal frame for river restoration in the EU. In this context, instead of constructing new hydropower dams and altering new river sections, the focus should be shifted to restoration and where feasible dam removal, while refurbishing and upgrading of existent plants must strictly ensure full compliance with the environmental legislation.

We hope that our articles will contribute to raise awareness on the numerous environmental challenges posed by hydropower dams and solutions to mitigate their impacts. Enjoy reading!

Hydropower balancing between global climate change and regional water protection

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Hydropower has been a human use for a long time. In many countries, it is a major pillar of electrical production. The consumption of energy is continuously increasing in parallel with population growth as well as quantitative and qualitative demands. In the emerging debate about global climate change and "sustainable" development, hydropower has gained increasing attendance. On the one hand, it is almost free of greenhouse gases (mainly CO_2, but some hydropower plants emit CH_4). On the other hand, it causes significant and often irreversible damage to freshwater ecosystems. Therefore, the advantages and disadvantages of hydropower plants must be balanced. This article provides a general overview and develops recommendations to mitigate impacts from hydropower.

Short Abstract of Hydropower History

Hydropower to operate machines (bucket wheels) was started some 5000 years ago in China and later used by all major ancient cultures (e.g., Mesopotamia, Greeks, Romans). At the end of the 18th century, when the industrial revolution began, hundreds of thousands of water mills were in operation. In 1880, the first hydropower plant was put into operation in England, followed in 1896 by the first large hydropower plant in the USA (de.wikipedia.org/wiki/Wasserkraft, visited 17.9.2020). A hydropower boom started after World War II due to economic and technical developments. Today, hydropower is classified as "old" renewable energy, in contrast to "new" renewable energy such as solar and wind.

The actual Energy Debate and Strategy

The newly launched global energy debate is dominated by two issues: First, the ever increasing human population demands more production of energy and electricity. In particular, the general quantitative demand is complemented by a qualitative demand, basically triggered by increasing welfare, mobility and globalization. Second, ongoing global climate change requires a drastic limitation of greenhouse gases, mainly CO_2 and CH_4; hence, decarbonization is on the political agenda, especially the substitution of oil products (Sustainable Development Goals UN 2015; Paris Agreement 2015). Every country has developed its own strategy, usually based on securing energy supply, particularly in winter. While the application of "sustainability" is indispensable, some still rely on oil and gas, and some on nuclear power and hydropower. New renewable energies have emerged and gained importance, mostly wind and solar energy. The strategy chosen is highly dependent on economic considerations as well as the share of basic and peak energy. The costs of production, the dynamics of the energy market, the price of electricity, and the gross national product all play a crucial role. Today, electricity is bought and sold within minutes on a floating market similar to a stock exchange. In addition, and in the debate about "sustainability", we need to consider decentralized versus centralized systems (Wilderer & Grambow 2016): The latter require substantial, costly transport and storage capacities.

Any energy strategy is in conflict with environmental protection, at the global as well as regional level. The basic question is whether humans, driven by economy and egotism, should ultimately destroy freshwater ecosystems as the basis of our lives (Boon et al. 2000). In particular, power plants using water are a focus in aquatic science, including nuclear power (thermal pollution through cooling systems) and hydropower (see below). Hydropower is in conflict between targets of global climate change mitigation and regional nature and water protection. In this context, it matters whether we deal with the construction of new plants or the refurbishment of existing plants. New concessions or permits require an Environmental Impact Assessment (EIA), including an analysis of the (near-) natural reference state of the river system affected upstream and downstream of the hydropower plant. They also require a deficit assessment by comparing the reference with the actual state and expected impacts, and a science based evaluation of the potential for mitigation or compensation. This procedure needs proper public participation. Ultimately, the quality of national environmental laws (the Water Framework Directive (WFD) in Europe) and the willingness of governments and authorities to implement laws deciding on sound solutions.

Recently, hydropower was positioned not only as producer of electricity, but also as multiple-use plants; e.g. for flood control and irrigation. For instance, climate change increases the dimension and frequency of flood events and can cause intensive droughts. Such trends increase the request of operators to value even small hydropower plants as an "overriding public interest". This complicates the political discussion because the conflict of interest is enlarged. In this context, natural floodplains should be conserved and restored.

Types of Hydropower Plants and Environmental Issues

The technology of hydropower plants is described in many textbooks (e.g. Hütte 2000). Nowadays, technical progress is mainly targeting the increase in production efficiency; e.g., modern turbines. With regard to installed capacity, we can distinguish between small hydropower (<10 MW), medium hydropower (10–100 MW) and large hydropower (>100 MW). Sometimes, other threshold values are used. For example, Hudek et al. (2020) classified hydropower plants with an installed capacity >10 MW as large, 1–10 MW as medium, <1 MW as small, and <0.1 MW as micro. It should be noted that a few large plants contribute to the majority of energy production, while many small plants provide a few percent (ICPDR 2013). Moreover, small hydropower plants, usually situated on small rivers or streams, have similar negative environmental impacts as those caused by large plants on large rivers; e.g., disruption of the river continuum. Therefore, small hydropower, promoted particularly by unsuitable subsidies in SEE countries in the Lower Danube region, cannot be used to combat climate change. Apart from hydropower size, general types include run-of-river (impoundment), diversion, and (pumped) storage plants *(fig. 1)*. The former are mostly in lowland regions, the latter mostly in steep mountain regions.

Hydropower: Pros and Cons in the Global and Regional Perspective (Danube River Basin)

From a global perspective, hydropower is almost CO_2-free except in the tropics and large lowland rivers where CH_4 is emitted from the sediment of reservoirs (Maeck et al.

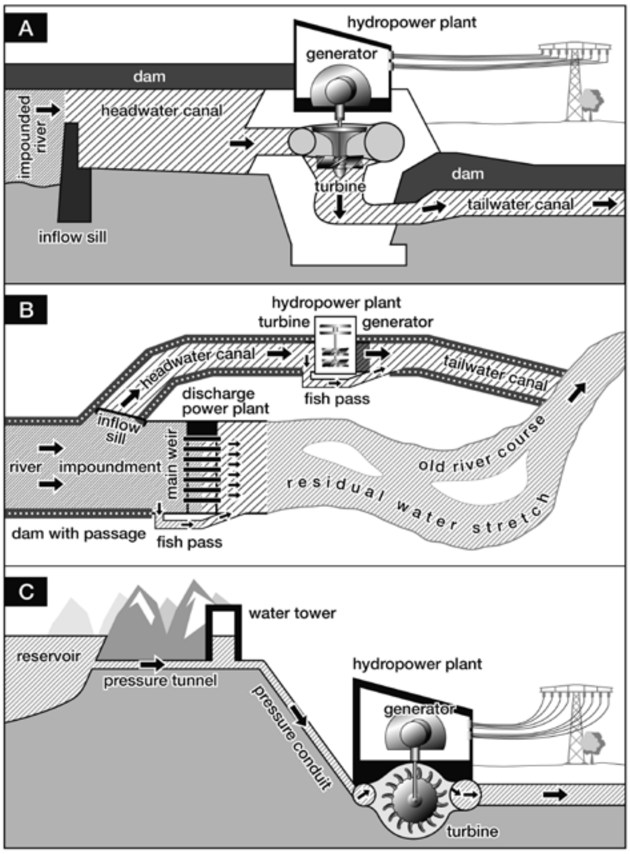

Figure 1: Technical schemes of various types of hydropower plants: (A) run-of-river plant, (B) diversion plant, (C) (pumped) storage plant. Credit: RAOnline EDU & Bayerische Landeskraftwerke, redrawn by Claudia Pietsch, CU Eichstätt-Ingolstadt

2013, Deemer et al. 2016, Scherer & Pfister 2016). However, is this a reason to rate hydropower as "sustainable" (Moran et al. 2018)? Scaling matters: from a regional to local perspective, rivers are heavily impacted by hydropower, which is a key pressure on aquatic ecosystems (hydrology, hydromorphology) and biodiversity (habitats and biota). In fact, the negative impacts often result in irreversible damage to aquatic ecosystems (Grill et al. 2019).

Major impacts of hydropower on riverine ecosystems are compiled in Table 1. Run-of-river plants mainly disrupt the river continuum. The impounded stretch is transformed into a lake ecosystem lacking riverine dynamics of hydrology (discharge). Over time, reservoirs fill with sediments and need to be flushed in light of stored contaminants and ecological thresholds of suspended solid concentrations. Further, groundwater tables are affected due to altered river infiltration and exfiltration. Diversion plants also cause mainly problems of residual water (ecological flow) and hydropeaking. Storage plants change alpine landscapes, the hydrological and sediment regime and cause significant hydropeaking effects. Sometimes, headwaters from other catchments are diverted to alpine reservoirs with mostly unknown ecological effects. Often, hydrological and temperature regimes are inverted seasonally, with artificial high flow and temperatures in winter (production mode) and low flow and temperatures in summer (storage mode).

The disruption of fish and zoobenthos migration as well as sediment transport by dams is obvious. For example, the Iron Gate dams on the Danube River, operational since 1972 and 1984, have stopped sturgeon spawning migration to the Middle and Upper Danube, thus disrupting their life cycle and threatening natural reproduction (Reinartz 2002). In the Iron Gate reservoir, contaminated sediments accumulate (Milenkovic et al. 2005). Downstream of the hydropower plant Freudenau in Vienna, sediment erosion amounts to some 1.5 cm/year, thus fostering riverbed incision (Klasz et al. 2016). Expensive sediment feeding for compensation and other environmental measures diminish the economic benefits of energy production. In impounded stretches, typical benthic fauna changes from lotic to lentic (Moog 2002, *fig. 2)*. Moreover, sediments become clogged by the settling of fine particles. In large alpine reservoirs, water temperatures downstream can be drastically changed when hypolimnetic cold water is released from the impoundment. In some rivers, one hydropower plant follows the other, and this chain of hydropower plants changes the free-flowing river into a chain

Impact	Ecological consequences	Measures of mitigation	Key literature
Dams, impoundments	Disruption of the river continuum, fish migration and sediment transport; change of habitats and fauna in the reservoir (lotic → lentic); inversion of the hydrological regime and water temperature; river bed incision, lowered groundwater table and disconnected floodplains downstream of the dam	Functional fish passes; (partial) sediment transport through the weirs, removal of barriers	Nilsson et al. (2005)
Water abstraction	Alteration of the hydrological regime (discharge)	Ensure minimum ecological flow with seasonal fluctuation	Bunn & Arthington (2002); Dyson et al. (2003)
Hydropeaking	Fast and strong increase/ decrease of flow affects fish and benthos	Allow a controlled regime by an adapted running mode or special retention basins (reducing amplitudes and slow down the flow changes)	Greimel et al. (2018)

Table 1: Major impacts of hydropower plants on riverine ecosystems (habitats and fauna)

of lakes (e.g., the Danube River has 52 dams upstream of Vienna, and many Danube tributaries have impoundments (ICPDR 2015).

Water abstraction drastically reduces discharge and flow, and many lotic species disappear because their living conditions are lost. In mountains, many stretches remain completely dry and without any aquatic biota *(fig. 3)*. Hydropeaking is another impact of the natural hydrological regime to which aquatic organisms are adapted by evolution. In contrast to stochastic floods and droughts causing high and low flow conditions over the season, hydropeaking is a regular, repeated and rapid change in flow: Both fish and benthos are swept away by the strong peaks in current, or they are stranded to die on shallow dry banks. An overall result is a drastic loss of biodiversity.

Mitigating Impacts to protect our rivers

In the hydropower sector, integrative river protection and management should provide the background

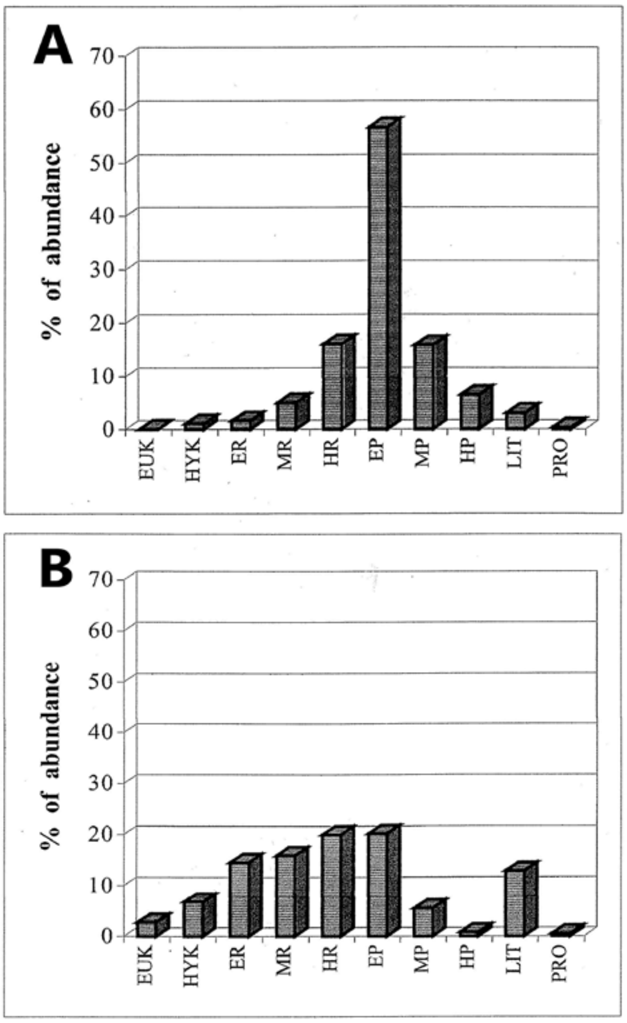

Figure 2: Changes of benthos communities due to impoundment by a hydropower dam. An example of River Traun, Upper Austria (Moog 2002). (A) Epipotamal character of the river (reference); (B) Region of Danzermühl (impoundment). River zonation: EUK = Eucrenal, HYK = Hypocrenal; ER = Epirhithral, MR = Mesorhithral, HR = Hyporhithral, EP = Epipotamal, MP = Mesopotamal, HP = Hypopotamal, LIT = Litoral, PRO = Profundal

guidelines (Bloesch et al. 2012). A general concept to be considered is the prioritization of conservation over restoration (Boon 2005). Mitigation measures need to be balanced in a cost-benefit analysis and should follow the sequence: avoid – mitigate – compensate the impact. Hence, we consider protected areas (national parks, nature parks, Natura 2000, etc) as "no-go zones" for new hydropower plants, but are accepted by authorities for exemptions according to Articles 6.3 and 6.4 of the EU Habitats Directive (Council Directive 92/43/EEC of 21 May 1992, ICPDR 2013). Many catchments in Lower Danube countries still feature free-flowing rivers that are under strong political pressure to promote hydropower (Schwarz 2016; Hudek et al. 2020). Theory and practice are not always in agreement, as demonstrated, e.g., by the hydropower case on the Jiu River in Romania (Dejeu & Carpa 2020) and the poor performance of the badly needed feasibility study for sturgeon fish passages at the Iron Gate dams. Clearly, implementation of the respective national environmental law is prescribed by the WFD and other relevant EU Directives. However, this is in conflict with the EU Energy Strategy and several EU Renewable Energy Directives combating greenhouse gas emissions and climate change.

To restore or ensure the river continuum, at least partly, dams and weirs need to be equipped with functional fish passes for upstream and downstream migration, as well as technical facilities to allow uncontaminated bottom sediment transport during high flow. In large rivers (about >300 m^3/s), two fish passes are needed because most fish migrate along the banks. Depending on the local situation, migration aids can be a technical fish latter, a fish lift, a fish lock, or a near-natural by-pass. The ICPDR (2015) documents numerous missing and built fish passes in the DRB, but without indicating their function. It is extremely difficult and debated to quantify and rate the proper function of a fish pass (Schmutz & Mielach 2013; ÖFV 2020). Key issues are flow attraction at the entrance and timely passability. Apart from technical controls of proper dimensions, a biological success control after construction is indispensable. To note, far less attention has been given to downstream facilities. Guiding barriers, screens and racks may be supported by so-called fish-friendly turbines with low fish mortality rates, but these need to be rated with utmost caution, particularly with regard to eels. A long-term monitoring of fish passes (success control) during the whole concession period is highly recommended.

Since around 2000, old and rather small or medium dams, where the negative environmental impacts outcompeted the economic benefits, became subject to dam removal (demolition), particularly in the USA, but also in Europe. Presently, some 4984 barriers have been removed already in 13 European countries (www.damremoval.eu).

Further, stretches with residual flow through water abstraction need to have minimum ecological flow (Allan 1995, Arthington et al. 2006). Since the amount of compensation water is debated as every liter given diminishes electricity production and thus profit, this topic requires very good scientific investigations. The negative effects of hydropeaking can be mitigated by reducing discharge amplitudes, by slowing the increase/decrease of flow, and by construction of special retention basins to offset high peaks. As mentioned above, floodplains need special treatment and protection.

A thorough impact analysis suggested above provides a set of measures of how to mitigate environmental damage. The Strategic Environment Assessment (SEA), Environmental Impact Assessment (EIA), and final concession (permit) provide the political basis for any large construction. These should be executed by the competent authorities in an open procedure, and using Public Participation (as prescribed by the Aarhus Convention). Simply organizing a public workshop for presenting finalized construction plans is quite insufficient. Local communities and the people affected as well as environmental NGOs should be involved in the process as early as possible, ideally before any plans are elaborated. Experience shows that the sincere cooperation between engineers, biologists, authorities, stakeholders and local people may be a laborious and difficult task, but at the end the project will be less expensive and better.

Figure 3: Madriser Rhine, Avers Valley, Grisons, Switzerland. Upstream and downstream of the water abstraction. The dried out river section has no aquatic life and disrupts the river continuum. Credit: SGS, Schweizerische Greina-Stiftung Zürich

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Balkan rivers are endangered by construction of new hydropower plants

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Abstract

1,480 operating hydropower plants (HPP) were recorded in the Balkan region and 108 are currently under construction, while 1,547 of 3,431 planned HPPs (45%) are located in Natura 2000 and other protected areas (e.g. National parks, Emerald sites, Ramsar sites). There has been a significant increase in HP development, with numbers of operating HPPs doubling between 2015 and 2020. The increase is predominantly, but not only, because of small and medium sized HPP construction that are mostly diversion type. This has led to thousands of kilometres of abstracted and interrupted rivers. Hence, the impacts of small and medium sized HPPs are disproportionately high, while their contribution to overall energy production is low. Furthermore, there are plans to construct HPPs on the Vjosa River, one of the last large free flowing rivers in Europe. There is a need to recognize the widespread impacts caused by HPPs, especially small and medium sized ones, in order to achieve the EU Biodiversity Strategy's aims to reconnect 25,000 kilometres of Europe's rivers by 2030.

1. Introduction

Rivers provide services essential to human well-being, but our use of rivers for power generation, water supply, flood control, navigation and other uses (Tockner et al., 2010) has nearly always involved their fragmentation. Instream structures, such as weirs and dams, have been developed in the past to such a global extent that only a minority especially of large rivers still remains unaffected by their environmental impacts generated (Belletti et al. 2020; Grill et al. 2019).

Weirs and dams may cause significant environmental impacts such as river fragmentation (Liermann et al. 2012), severe modification of river flow (Zimmerman et al. 2010) and temperature regime (Žganec 2012; Zolezzi et al. 2011), dramatic reductions in sediment transport (Hauer et al. 2018) and hydro-morphological degradation of extended downstream river sections (Wiatkowski & Tomczyk 2018). Together they lead to the habitat loss and loss of biodiversity, ecological functions, ecosystem services as well as system resilience resulting in a significant impairment of the ecological integrity of river ecosystems (Richter et al. 2003).

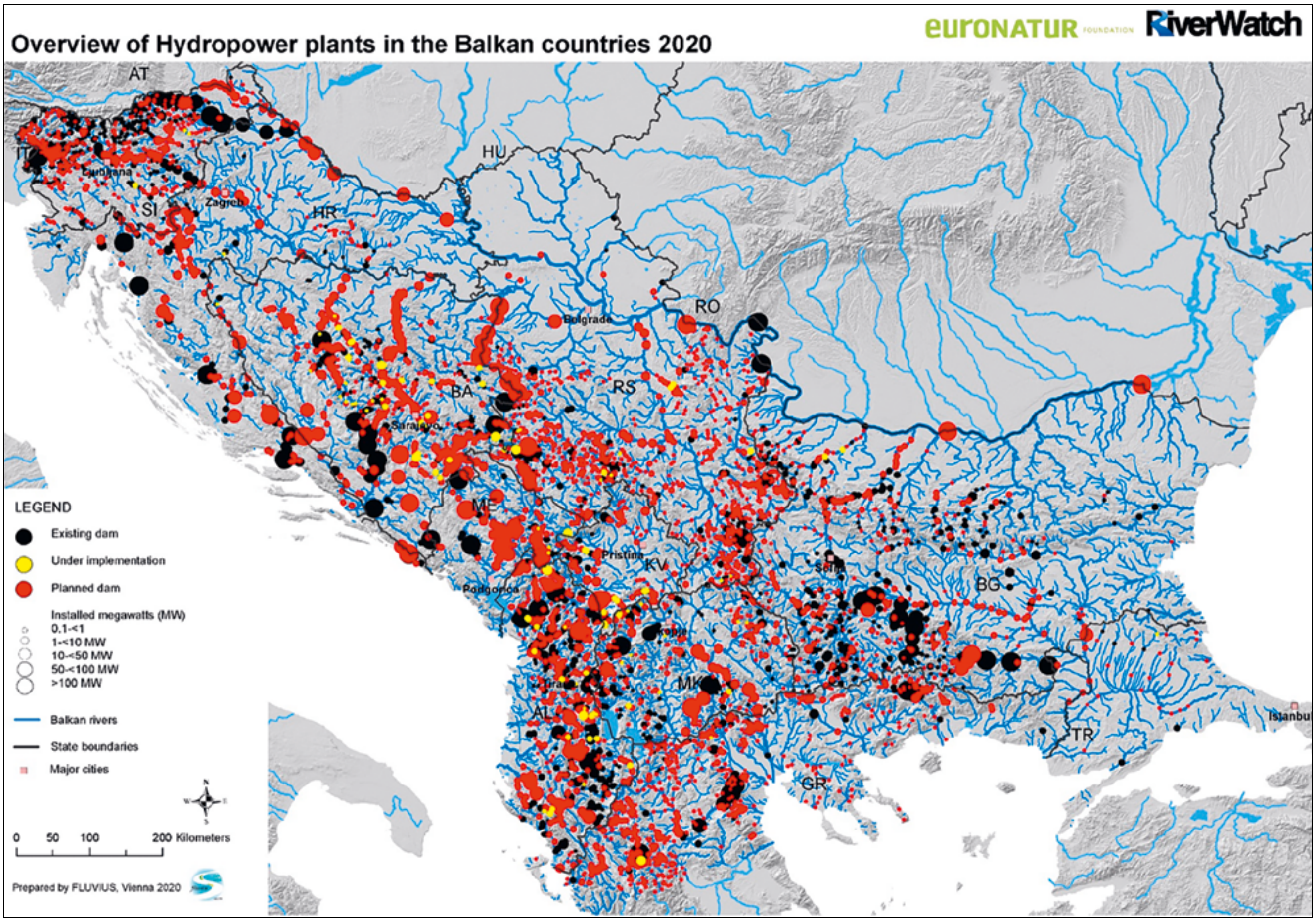

Figure 1: *Distribution of existing (black circles) and planned (red circles) hydropower plants and hydropower plants under implementation (yellow circles)*

Relatively unfragmented rivers are still found in the Balkan region, the Baltic states and parts of Scandinavia and southern Europe (Belletti et al. 2020). According to Schwarz (2012a), the morphology of up to 80% of rivers, of a total of 35,000 km of rivers in the Balkan region, had been assessed as still having a good condition. This was by far the highest percentage in Europe, where 80% of rivers have been found to be in poor hydro-morphological condition. For biogeographical reasons, the river systems of the Balkan region are home to very diverse and highly endemic freshwater fauna (Ćaleta et al. 2015; Freyhof 2012; Griffiths et al. 2004; Ivković & Plant 2015; Schiemer et al. 2020; Weiss et al. 2018), and therefore have been identified by the WWF as one of the key places (Global 200 Ecoregions) for biodiversity conservation on a global scale. For example, 49 (11 endemic) of 113 freshwater fish species in the Balkan region are faced with either the threat of extinction or loss of between 50 and 100% of their distribution (Weiss et al. 2018).

All EU countries as well as some non-EU states have established national plans aiming to reduce greenhouse gas emissions that include financial subsidies (e.g. feed-in-premium) for renewable energy production including hydropower (Gallop et al. 2019). These in turn, have triggered a revival in the construction of weirs and dams for hydropower production (HPPs), especially small HPP (Huđek et al. 2020; Schwarz 2020; Zarfl et al. 2014). Like in many other regions of the world, the Balkan area is currently planning to develop significantly more HPPs on many rivers that have so far mostly remained undammed (Huđek et al. 2020; Schwarz 2020; Zarfl et al. 2014). Already the hydropower boom in the last decade, especially in countries like Albania, Bosnia and Herzegovina, but also Serbia devastated numerous rivers. Furthermore, there are plans to build HPP even in national parks and other protected areas (e.g. EU Natura 2000 sites, regional parks) (Schwarz 2020, 2012b), which would have a massive impact on river ecosystems in the Balkan region. Therefore, rivers of the Balkan region require urgent protection from proposed dam developments (Belletti et al. 2020).

Here we present the distribution and trends of existing and planned hydropower plants in the Balkan region.

2. Study area

The study area comprises the EU countries Slovenia (SI), Croatia (HR), Bulgaria (BG) and the northern Balkan area of Greece (GR), as well as the non-EU countries Bosnia & Herzegovina (BA), Serbia (RS), Montenegro (ME), Kosovo (KV), North Macedonia (MK), Albania (AL), and the European part of Turkey (TR).

	Existing	Planned	Under implementation
Slovenia	366	375	3
Croatia	60	147	1
Bosnia and Herzegovina	139	390	35
Serbia	122	824	14
Kosovo	22	87	10
Montenegro	20	92	4
North Macedonia	99	193	12
Albania	290	410	24
Greece	50	565	2
Bulgaria	307	323	2
Turkey	5	25	1
In protected areas*	675	1547	48
Total	1,480	3,431	108

**National parks, Ramsar sites, Biosphere Reserves, World Heritage sites, Natura 2000 network, Emerald sites, Landscape protection*

Table 1: Number of existing, planned and under implementation hydropower plants in the study area and in the protected areas of study area

3. Material & Methods

For more information see the report of Schwarz (2020).

4. Results & Discussion

1,480 operating HPPs were recorded in the study area, 89% of which were small (≤10MW) and 108 are currently under construction *(tab. 1; fig. 1; fig. 3)*. The largest number of operating HPPs was located in Slovenia (N = 366), followed by Bulgaria (N = 307) *(tab. 1)*. A large number of HPPs, 3,431, are in the planning phase, 92% of which are small (≤10MW). Serbia, Bosnia and Herzegovina, Albania and North Macedonia are current hotspots of HPP construction, while in Greece the large number of planned HPPs (N = 571) seems to remain fictive (tab. 1).

1,547 of 3,431 HPPs (45%) are planned in Natura 2000 and other protected areas (e.g. National parks, Emerald sites, Ramsar sites) *(tab. 1)*. In national parks in Bosnia and Herzegovina, Kosovo, North Macedonia and Albania currently at least 14 HPP are under construction.

The designation of many rivers as Natura 2000 areas, in Croatia or Bulgaria, has led to a reduced development of HPPs. However, non-EU countries have not developed Natura 2000 network yet. For example, the total inland area designated as protected in Bosnia and Herzegovina and Serbia is small; indeed, the percentage of total state territory is significantly below the European average (1.4% in Bosnia and Herzegovina, 7.56% in Serbia) (Appleton et al. 2015b, 2015a). This means that the percentage of planned HPPs that would significantly affect species that are protected in the EU under the Natura 2000 network would be high. Furthermore, the booming HP sector in the Balkan region defies the EU's political ambitions of improving the state of rivers in line with the Water Framework Directive and to reconnect 25,000 km of rivers by removing dams and water abstraction systems.

There has been a significant increase in hydropower development, with numbers of operating plants doubling between 2015 (N = 714) and 2020 (N = 1480) *(fig. 3)*. Hot spots of HPP development in the recent years are Albania, Bosnia and Herzegovina, followed by Serbia, North Macedonia and Kosovo. The increase is predominantly because of small HPP construction that are usually diversion type, but also of some larger dams e.g. on Devoll in Albania (Moglice). Diversion HPPs operate by water abstraction from an upstream reservoir or river reach and transport through pipe to a hydroelectric powerhouse located more downstream in order to increase the difference in hydraulic head for power generation. This operation type raises the risk of the river channel to fall dry in the river reach between the dam and the return point of abstracted water *(fig. 2)*. This has already led to hundreds, even thousands of kilometres of abstracted rivers and habitat destruction, as well as to deforestation and erosion in order to build access roads. Local people have been often left without water for irrigation and livestock (Gallop et al. 2019). The amount of flow abstracted for hydropower generation can vary widely depending on national, regional, or local regulations. However, those regulations are often disregarded. HPP projects, particularly small diversion schemes, are the most important driver of potential fish species extinctions in the Mediterranean Basin Biodiversity Hotspot (Freyhof et al. 2020).

Furthermore, the pressure of climate change argumentation and renewable energy policies (e.g. EU Renewable Energy Directive) encourage the ongoing HPP development. In fact SHPP development does not contribute much to electricity share if we see that in 2018, SHPPs generated only 3.6 per cent of electricity overall, but received 70 per cent of renewable energy incentives in the Western Balkans (Gallop et al. 2019). Renewable energy incentives were received mostly through feed-in tariffs and they are considered as the main driver for SHPPs and the main burden on bill payers. There is the obvious conflict of interest between EU strategies for the development of renewable energy (EU RES) and for the protection of biodiversity (International Convention of Biological Diversity, EU Biodiversity Strategy, Natura 2000 network). There is a need for the harmonization of EU and national policies on the development of renewable energy

Figure 2: Small hydropower plant Garvanitsa on Strane River in Bulgaria. Operation of this HPP causes regular drying of Strane River's riverbed; credits: dams.reki.bg

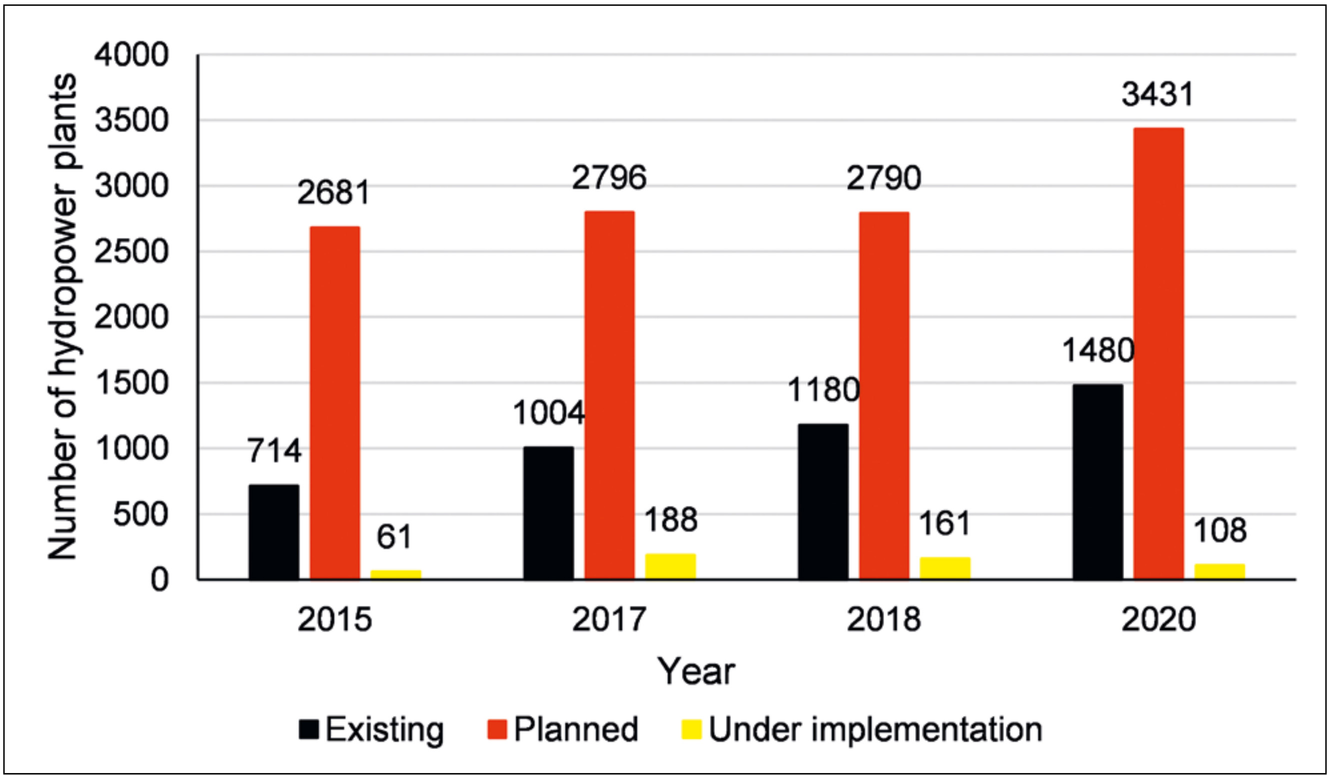

Figure 3: Number of existing, planned and under implementation hydropower plants in years 2015, 2017, 2018 and 2020

sources, on water management and on nature conservation in rivers and floodplains.

Conclusions

Numbers of operating HPPs doubled between 2015 and 2020. The increase was predominantly because of small and medium sized HPP construction that are mostly diversion type. The environmental impacts of small and medium sized HPPs are disproportionately high, while their contribution to overall energy production is low (Huđek et al. 2020). Therefore, there is an urgent need to mitigate the escalating ecological damage caused by the boom in HPP construction through preservation and restoration of free-flowing rivers. In addition to small HPPs also larger HPPs are planned on some of the most valuable rivers from the ecological point of view in the Balkan region e.g. on Vjosa (AL), Morača (ME) but also on upper Sava (SI), Vrbas (BA), Bosna (BA), Drina (BA, RS), Vardar (MK) or Maritsa (BG). Vjosa River is one of the last large free flowing rivers in Europe and should be subjected to protection as national park instead of being exploited for hydropower. In order to achieve the EU Biodiversity Strategy's aims of improving the state of rivers and to reconnect 25,000 km of rivers by removing dams and water abstraction systems will require recognition and prevention of the widespread and devastating impacts caused by HPPs.

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Fish Ecological Monitoring at Innovative and Conventional Hydropower Stations in Bavaria, Germany

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Abstract

The use of hydropower is ambivalent, providing a contribution to decarbonisation of energy supply on the one hand, and impacting aquatic habitats and their connectivity with consequences for fish and biodiversity on the other hand. The aims of this project were to compare different types of innovative and conventional hydropower technology in terms of direct and delayed fish mortality, external and internal fish injuries as well as the impacts on habitat quality and aquatic biodiversity up- and downstream of the hydropower dams. The main findings suggest considerable species- and site-specific mortality and injury patterns that are strongly governed by local fish communities as well as construction aspects (such as screen properties, turbine type, hydraulic head) and operational modes. In contrast to the expectation, innovative technologies were not generally less harmful to fish than conventional ones equipped with specific fish protection screens. Even within one type of technology, site-specific differences strongly governed the observed impacts. The main impact on habitat quality and aquatic community structures was a result of the dam construction, irrespective of the installation of hydropower turbines. The observed seasonal and diurnal patterns of downstream fish movement along different corridors as well as the findings on fish mortalities and injuries can be used for an objective discussion on reducing adverse ecological effects of hydropower utilisation including its operational management.

Introduction

The contribution of hydropower utilisation to energy decarbonisation on the one hand, and its ecological impacts on river ecosystems, fish and aquatic biodiversity on the other hand, all contribute to the controversy on whether hydropower utilisation should be considered a “green” or “red” energy (Geist 2021). Minimising the ecological impacts of hydropower utilisation has become a target of conservationists and hydropower producers alike, requiring information on the impacts of different types of hydropower plants on fish mortality and injury patterns as well as the impacts on physicochemical habitat quality and biota other than fish. A systematic and comparative analysis based on field experimentation was conducted in the course of the project “Fish Ecological Monitoring at Innovative and Conventional Hydropower Plants” at the Chair of Aquatic Systems Biology of Technical University of Munich, Germany, funded and supported by the Bavarian State Ministry of the Environment and Consumer Protection and the Bavarian

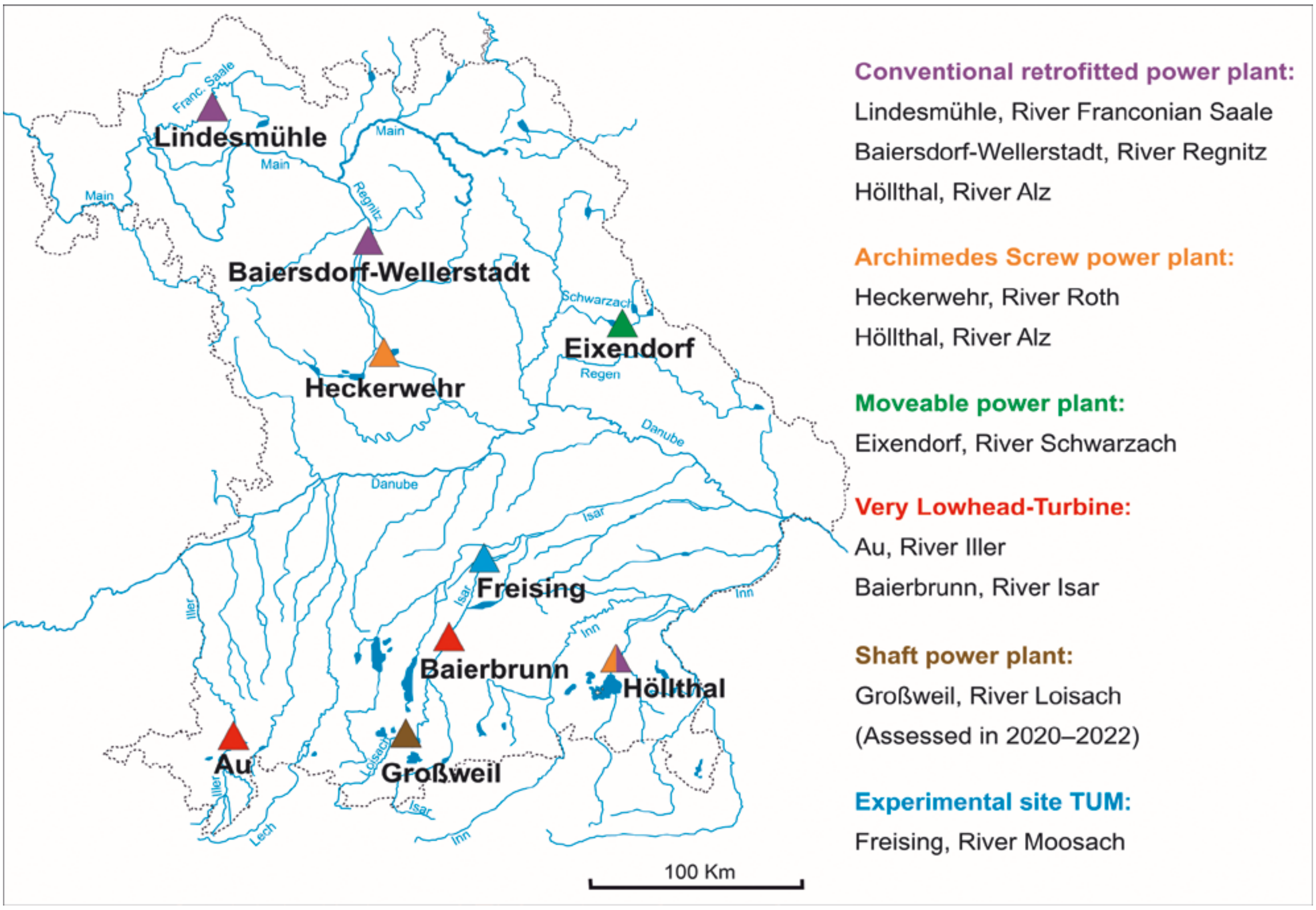

Figure 1: Study sites of the project on innovative and conventional hydropower production in Bavaria, Germany, comprising eight hydropower stations and one experimental site for pre-testing

Environment Agency. This project combines investigations into direct and delayed effects of downstream passage on fishes with characterisations of observed habitat changes. It commenced in 2014 and is currently in its final phase.

Methods

The study was conducted at eight different hydropower sites and one experimental site for pre-testing in Bavaria, Germany *(fig. 1).* The project established several meth-

Figure 2: Setting up catch nets for investigating mortalities and fish injury patterns downstream of a hydropower plant. Photo credit: Martin Erd

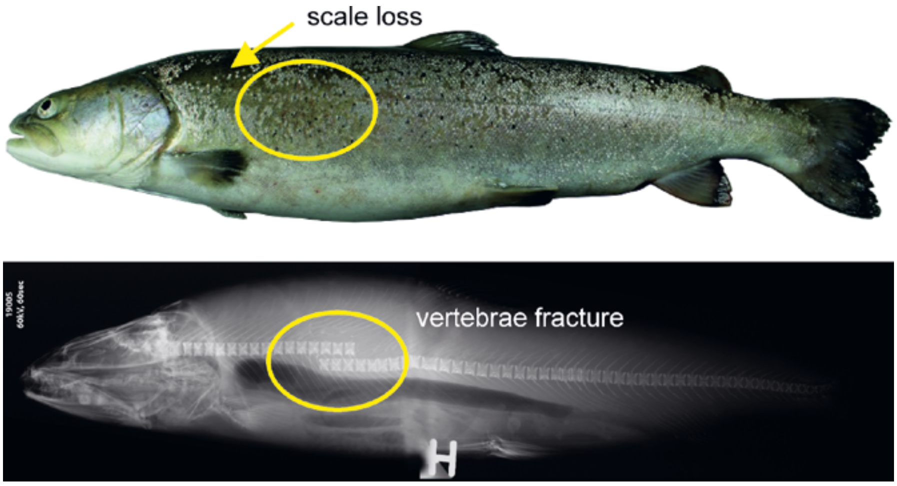

Figure 3: External (scale loss, upper picture) and internal (backbone fracture, lower picture) injuries of the same Danube salmon (Hucho hucho) following downstream passage of a hydropower facility

odological procedures, which are already detailed in other publications. This comprises investigations into an improved understanding of the effects of net-based catching techniques on observed mortality and injury patterns (Pander et al. 2018), including the behaviour of fish inside catch nets (Smialek et al. 2021), as well as establishing protocols for external (Mueller et al. 2017) and internal (Mueller et al. 2020) fish injury patterns that were also linked to the physical and hydraulic forces of turbine passage using technical sensor fish (Boys et al. 2018). The field experiments required the installation of big catch nets at each of the possible downstream migration corridors *(fig. 2)* to study corridor choice as well as corridor-specific mortalities and injury patterns *(fig. 3)*. An ARIS sonar was used to study the behaviour of fish, in particular (silver) eels approaching hydropower facilities on their downstream migration *(fig. 4)* as recommended in Egg et al. (2018). To investigate the impacts of hydropower facilities on habitat quality and aquatic biodiversity, habitat changes and aquatic community structure up- and downstream the facilities were compared *(fig. 5).*

Results and Discussion

The results of the study provided several new insights into the effects of hydropower at the investigated sites. Fish mortalities and fish injury patterns strongly differed depending on the local fish community, the site-specific construction effects (e.g., turbine types, hydraulic head) as well as the operational modes. All results are available via the official project website under www.lfu.bayern.de/wasser/fischschutz_fischabstieg/ergebnisse and https://www.fisch.wzw.tum.de/aktuelles.html. In contrast to the initial hypothesis, innovative hydropower solutions, which are often presented as being particularly “fish friendly”, did not always result in lower species-specific mortalities than conventional ones equipped with fish protection screens. Rather, under certain conditions (e.g., low hydraulic head, slow rotational speed) conventional turbines caused fish mortalities comparable to or even lower than those of the examined innovative turbine types. Even the same technologies used at different sites revealed differences in species-specific effects related to differences in discharge, hydraulic head, available corridors for downstream migration and the species inventory.

Another key finding was that the lengths of the majority of fish specimens caught from natural downstream movement was < 15 cm and thus not effectively protected from entrainment by most screen types. Moreover, at most sites the majority of downstream moving fish used the turbine corridor, despite the installation of different bypass systems (e.g., crest cut-out in movable power plant, see Knott et al. 2019). Only at one site, where a 40 m wide rock ramp

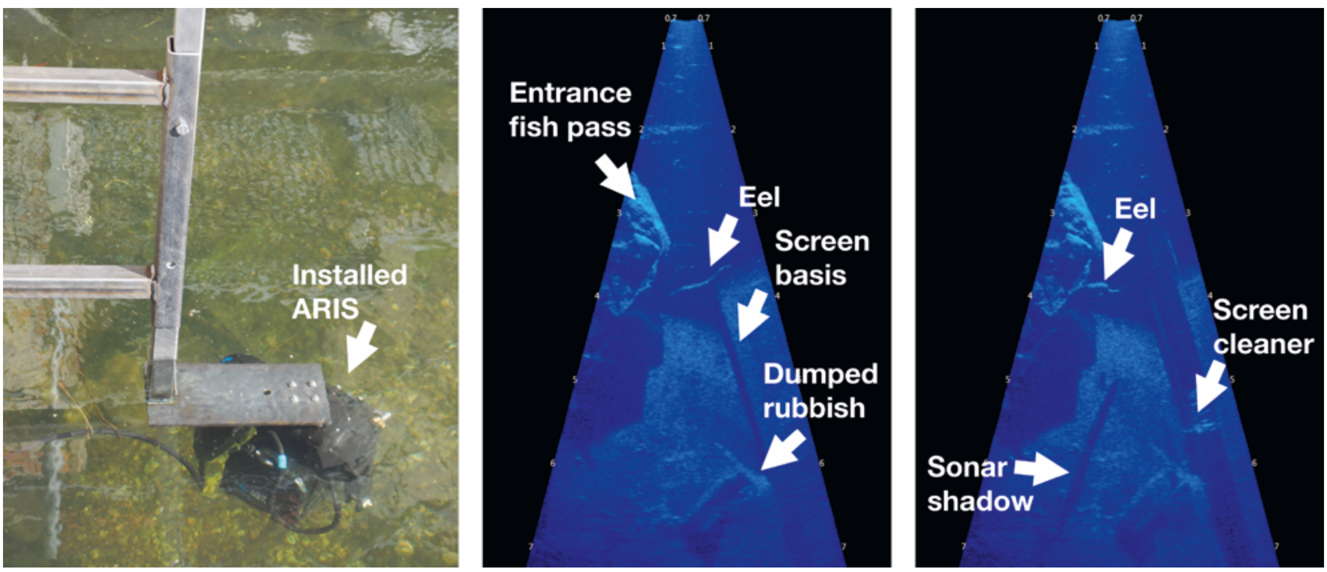

Figure 4: Investigation of fish behaviour is also important in understanding corridor choice. In the project, an ARIS sonar was used

combined with a technical fish pass was positioned directly next to the turbine inlet covering 31% of the discharge, the majority of downstream moving fish (70%) used the ramp, and an additional 10% the technical fish pass. Further, a zig-zag tube system efficient for facilitating silver eel downstream passage in laboratory experiments (Hassinger & Hübner 2009) was found to be not efficient in the field setting. Instead, downstream migrating eels strongly responded to the opening of an undershot sluice gate, which thus provided an efficient corridor for downstream passage (Egg et al., 2017). For future planning, considering optimal positioning and sufficient water dotation for alternative corridors than the turbine pathway is key to impact reduction.

Typical injuries included amputations, scale loss as well as internal injuries such as swim bladder rupture (Mueller et al. 2017, 2020), which could be explained by the physical and hydraulic forces experienced during turbine passage (Boys et al. 2018). The observed strong seasonal and diurnal differences in downstream movement patterns (Knott et al. 2020) suggest that adjustment of operational modes according to the main movement times may be suitable to substantially reduce the negative impacts of the facilities on fish. Concerning the impacts of hydropower utilisation on physicochemical habitat quality, in most cases only marginal differences in the abiotic habitat properties and the biological community structures were observed comparing time points before and after installation of the innovative hydropower technologies. This strongly indicates that the main effect on serial discontinuity was already introduced by the dams and weirs (Mueller at al. 2011), irrespective of the installation of hydropower turbines.

The findings of the study provide a natural-scientific background for decision-making, which now also needs to include other aspects and disciplines such as engineering and socio-economic considerations (Geist 2021). Furthermore, the findings of this project provide a basis for comparison with future technological developments, which all deserve a chance, but need to be objectively evaluated with respect to their impact.

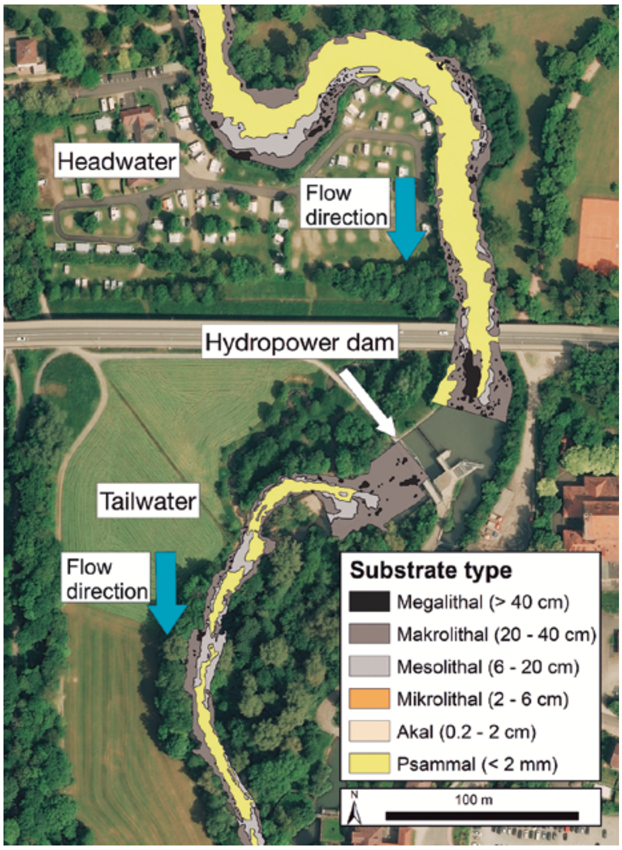

Figure 5: Substrate mapping in up- and downstream areas of hydropower sites conducted as part of the habitat effect assessment

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Ecological consequences of the construction of the Iron Gates and Gabčíkovo dams and prospects for mitigating the effects on migratory fish species

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The largest hydropower plants constructed on the Danube River

Starting from the Black Sea and upstream along the Danube River, the first dam and barrier for anadromous fish species on their spawning migration from the Black Sea and the Danube Delta is the Iron Gate II hydroelectric power plant (HPP) that was completed in 1984 at river km 863. The second obstacle is Iron Gate I at river km 943 that started operating in 1970, and the third is the Gabčíkovo HPP on river km 1816, completed and put into operation in 1992 *(fig. 1)*.

The Iron Gates are the largest hydropower dam and reservoir system along the Danube River, and are jointly operated by Romania and Serbia. The Gabčíkovo HPP is the second largest dam on the Danube and is operated by Slovakia. There are no fish passes on any of these dams and reopening of Iron Gates I and II could unlock an additional 900 km for the migration of anadromous fish species, with suitable wintering, spawning, nursery and feeding habitats. Similarly, reopening of the Gabčíkovo HPP could enable migratory fish to reach Vienna upstream.

The impact of damming on migratory fish species

In the past, beluga sturgeons *(Huso huso)* migrated in the Danube River up to Bratislava in Slovakia (river km 1,860–1,870), with a few records in the Austrian and even German (Bavarian) stretch of the Danube River up to Straubing, river km 2,320 (Reinartz 2002). Russian sturgeons *(Acipenser gueldenstaedtii)* regularly reached Bratislava but rarely travelled as far as Vienna and Regensburg, while stellate sturgeon *(Acipenser stellatus)* rarely came upstream to Komárno and Bratislava (Reinartz 2002).

Anadromous migration represents a life history characteristic that increases the sensitivity of fish species to human-induced mortality. Overfishing of sturgeon due to their valued caviar was one of the main reasons for their decline. Records of a decreasing trend in sturgeon catches in the 16th century were noted in Hungary, with constant subsequent overfishing that caused large migratory sturgeons

Figure 1: The Iron Gate dams I and II and the Gabčíkovo dam (map: ICPDR)

Figure 2: a) Pontic shad, Alosa immaculata, caught in the Danube River downstream of Iron Gate II near Prahovo (Višnjič-Jeftić 2012) b) Azov shad – Alosa tanaica, caught upstream of Iron Gate II (Mihajlovac Bay) in May 2016 (Photo credits: Katarina Tošić)

to become an occasional catch in the Hungarian section of the Danube in the 19th century (Guti 2006). Habitat changes in the second half of the 19th century further negatively impacted sturgeon migration along the Danube, while construction of the Iron Gates restricted migration to the Middle Danube.

Only two catches of beluga sturgeon (in 1972 at river km 1613 at Ercsi, and in 1987 at river km 1531 at Paks) have been reported in Hungary since the onset of the Iron Gates' operation (Guti 2006). The construction of Iron Gates I and II prevented the migration of anadromous fish species (sturgeons, shads) to the Middle Danube. According to the FIThydro project (Fish Friendly Innovative Technologies for Hydropower – https://www.fithydro.eu), sturgeon is classified in the group of 18 fish species of "highest sensitivity" (species under very high risk during hydropower operation) among 148 native European fish and lamprey species. This negative impact of Iron Gates I and II was evident on sturgeon as fish passes were not constructed, and as compensation for blocking fish migration, a sturgeon hatchery was built in the locality of Mala Vrbica (Serbia), 16 km downstream of Iron Gate I dam, but it is not in function anymore.

Migration of shad (Pontic shad, *Alosa immaculata, fig. 2a;* Azov shad – *Alosa tanaica, fig. 2b)* was also interrupted by the construction of the Iron Gates. In the past, isolated individuals of Pontic shad migrated for spawning into the Danube as far as Budapest (river km 1650, Bănărescu 1964). New data based on eDNA analysis performed within the Joint Danube Survey 4 (JDS4) and MEASURES project (Managing and Restoring Aquatic Ecological Corridors for Migratory Fish Species in the Danube River Basin – http://www.interreg-danube.eu/approved-projects/measures) revealed that Alosa sp. was recorded at 954 river km (Pont et al. 2021), which showed that shad specimens could pass through both Iron Gates via ship locks.

Not only anadromous migratory fish species are affected by the Iron Gates but also semi-anadromous populations of vimba bream *(Vimba vimba),* which migrate upstream from brackish waters into rivers for spawning, as well as potamodromous freshwater populations of vimba bream that exist in the Danube. Other potamodromous migratory fish species, such as sterlet *(Acipenser ruthenus),* sabre carp *(Pelecus cultratus),* common nase *(Chondrostoma nasus),* barbel *(Barbus barbus),* asp *(Leuciscus aspius)* and Danube carp *(Cyprinus carpio),* could also suffer from a lack of access to spawning and nursery habitats due to the loss of connectivity. Telemetry investigation of European catfish *(Silurus glanis)* carried out downstream of Iron Gate II showed that it migrated upstream during the spawning period, and that the dam and ship locks were obstacles for its migration (Lenhardt et al. 2021).

In the case of Gabčíkovo HPP, the true loser was the inland delta of the Danube, the last large wetland of Europe (Balon & Holčik 1999). The Gabčikovo Water Project, which included dam construction and canalizing, destroyed most of the 230 km^2 of wetlands that have become almost permanently separated from the main channel. The Gabčíkovo HPP is a system of three dams, the upper dam (Čunovo) obtains water from the old Danube channel to the derivation canal that is blocked by the lowermost dam (Gabčíkovo). The discharge of the old Danube channel has decreased to one fourth of the average discharge of the former Danube. This has led to a decrease of the water level in the old Danube channel, and a system of dikes was built to maintain the water level in the remaining inland delta side arms system. The inland delta system of side arms was one of the most important spawning areas for migratory fish species, and it is now connected with the old Danube channel only during high floods. In general, the Gabčíkovo HPP has impacted not only longitudinal but also lateral connectivity. This has led to a decrease in fish abundance by a third (Černý et al. 2003), which continues unabated (Kováč, personal communication).

Possibilities for construction of fishways on HPPs

There have been many attempts to make the Iron Gates passable for migratory fish species. A scoping mission for the preliminary assessment of the feasibility of providing free passage to migratory fish species at Iron Gates I and II was organized in May 2011 by the FAO (Comoglio 2011). It involved different stakeholders, including representatives from the Romanian and Serbian Hydropower Company. Experts that participated in the mission suggested possible solutions for the management of upstream and downstream migrations over and around the dams. Potential solutions for upstream passage included a close-to-nature type of fish pass (bypass channel), a technical fish pass, a fish lift, as well as possible use of a navigation lock for fish passage. Suggestions for downstream passage included surface guide walls in the forebay of the HPPs that would lead fish towards surface bypasses. Following the FAO scoping mission, the project "Fish Migration at the Iron Gates I and II" further developed some of the most promising solutions for fish migration (De Bruijne et al. 2014). The prefeasibility study at the Gabčíkovo dam has also identified the most promising solutions (van de Kamp el al. 2014).

The main objective of the project "Fish Behaviour Preparatory Study at Iron Gate Hydropower Dams and Reservoirs" (DDNI 2015) was to restore fish migration on the Danube River by focusing on the main migration barrier (the Iron Gate hydropower dams between Romania and Serbia) as part of the legal requirements under the Water Framework Directive. Specific objectives were as follows: (1) to test and adapt different telemetry techniques (radio and acoustic) on sturgeons in order to identify the resolution required to precisely determine the preferred location of the fish pass entrances at the Iron Gate hydropower and navigation system, and (2) to prepare and train sturgeon tagging and tracking teams from Bulgaria and Serbia by a Romanian team in order to become partners in the forthcoming larger telemetry study *(fig. 3).*

The project MEASURES was initiated in 2018 and will be completed in 2021. The main aim of the project is to improve the conservation measures of endangered migratory fish species at the Danube basin by identifying and fostering the connectivity of habitats, and by promoting the establishment of ecological corridors. A map of migratory fish habitats has been prepared within the framework of this project. It shows that with a reopening of the Iron Gates there will be suitable wintering, spawning, nursery and feeding habitats upstream, meaning sturgeons and other migratory species would be provided with adequate conditions for reproduction and juvenile growth upstream of the dams (http://www.interreg-danube.eu/approved-projects/measures).

The project "Facilitating Fish Migration and Conservation at the Iron Gates" (WE PASS) started in 2018 with the main goal of preserving and reestablishing the migration route of endangered fish species in the Danube, specifically at the Iron Gates. Monitoring of fish behavior at Iron Gates I and II by acoustic telemetry is one of the aims of this

Figure 3: *Hands-on training of teams from Bulgaria and Serbia by the Romanian team on handling and surgical implanting of acoustic transmitters in the body cavity of sub-adult beluga sturgeon (total length 165 cm) using the electro-narcosis tube, Lake Sărulești (March 11, 2015)*

project. The other task relates to the building of models of the Iron Gate dams using hydrological and technical data (https://www.we-pass.org/).

In the area of the Gabčíkovo HPP, several LIFE projects that are currently running are focused on the interconnection of the inland delta or some side arms with the main Danube or old Danube channels. The LIFE + project "Restoration and Management of Danube Floodplain Habitats" aims to provide greater lateral connectivity. A newly submitted LIFE integrated project, "Implementation of the River Basin Management Plan in Selected River Sub-basins in Slovakia", will deal with complex and long-term proposals for restoration actions, particularly for the Danube River section in Slovakia, including fish migration and how to overcome barriers of the Gabčíkovo HPP.

Conclusion

The absence of fishways on the largest dams on the Danube River (Iron Gates and Gabčíkovo) make them mostly impassable for migratory fish species apart from the random passage of some fish via navigation locks. The negative impact on populations of migratory fish species is evident, especially on sturgeons. First steps in solving this problem were initiated in 2011. Since then, several projects have been completed and some are still ongoing, indicating a positive development in making the Iron Gates and Gabčíkovo dams traversable for fish. The construction of fishways would enable sturgeon to reach the majority of their historical spawning habitats.

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Mitigating ecological impacts of hydropower

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Introduction

Impacts on riverine ecosystems as a consequence of using rivers for hydropower (HP) production can be mitigated in various ways, whereby possibilities for gaining ecological benefits depend on many factors such as type and dimension of HP plant, river type of concern and other existing stressors. In principal, mitigating negative impacts is important throughout the entire HP planning as well as during pre- and post-implementation processes.

Mitigating impacts by strategic planning of HP

Mitigation starts at the planning stage, where dam siting decides in which way and to what extent catchments may become affected by HP use. Considering e.g. major fish migration routes, sensitive habitats and/or sites of high conservation value already during the dam siting safeguards environmentally-friendly implementation of HP. The ICPDR has developed a guidance document employing a number of economic and ecological criteria for classifying river sections from "favorable" to "non favorable" for HP use (ICPDR 2013). Following these guiding principles, new regulations for HP planning have been implemented in Austria at the provincial level and other countries (e.g. Bosnia and Herzegovina).

Mitigating impacts during and after HP implementation

Nowadays, a number of well-tested mitigation measures are available to improve the ecological conditions related to river continuity, sediment transport, hydrology, river morphology and water quality. Guidelines or guiding documents have been developed and are subsequently updated at national, European or international level supporting the planning and implementation of effective mitigation measures *(tab. 1).*

Potential ecological impacts	Mitigation measures	Examples of guidelines, guiding documents
Disruption of fish migration (upstream and downstream)	Upstream/downstream fish passes, fish screens, fish friendly turbines	Guidelines for building fish migration facilities (BMLFUW 2012)
Disruption of sediment transport	Sediment flushing/dredging, re-introduction of sediments	How-to Guide: Hydropower Erosion and Sedimentation (IHA 2019)
Impounded habitat – loss of fluvial habitat	Habitat restoration Habitat substitution	Stream and Watershed Restoration: A Guide to Restoring Riverine Processes and Habitats (Roni & Beechie 2012)
Water abstraction	Release of ecological-flow	Ecological flows in the implementation of the Water Framework Directive: guidance document n°31 (EC 2016)
Reservoir water level fluctuation	Reduce water level fluctuations, manage shallow habitats	WG ECOSTAT report on common understanding of using mitigation measures for reaching Good Ecological Potential for heavily modified water bodies Part 1: Impacted by water storage (Halleraker et al. 2016)
Hydropeaking	Installation of a balancing reservoir, changing HP operational mode, diverting peak flows	
Downstream water quality deterioration incl. water temperature alteration and oversaturation	Flexible/multiple intakes, avoid air mixing into turbine intake	

Table 1: Potential ecological impacts caused by HP, mitigation measures and examples of guidelines

While there is comparably long tradition in implementing ecological flows and fish passes, improving the ecological conditions in “heavily modified water bodies – HMWB” sensu EU Water Framework Directive (WFD) is still challenging due to ecosystem degradation and potential impacts on use resulting from mitigation measures. This happens especially in case of large impoundments/reservoirs that fundamentally change the former fluvial habitat conditions and/or may

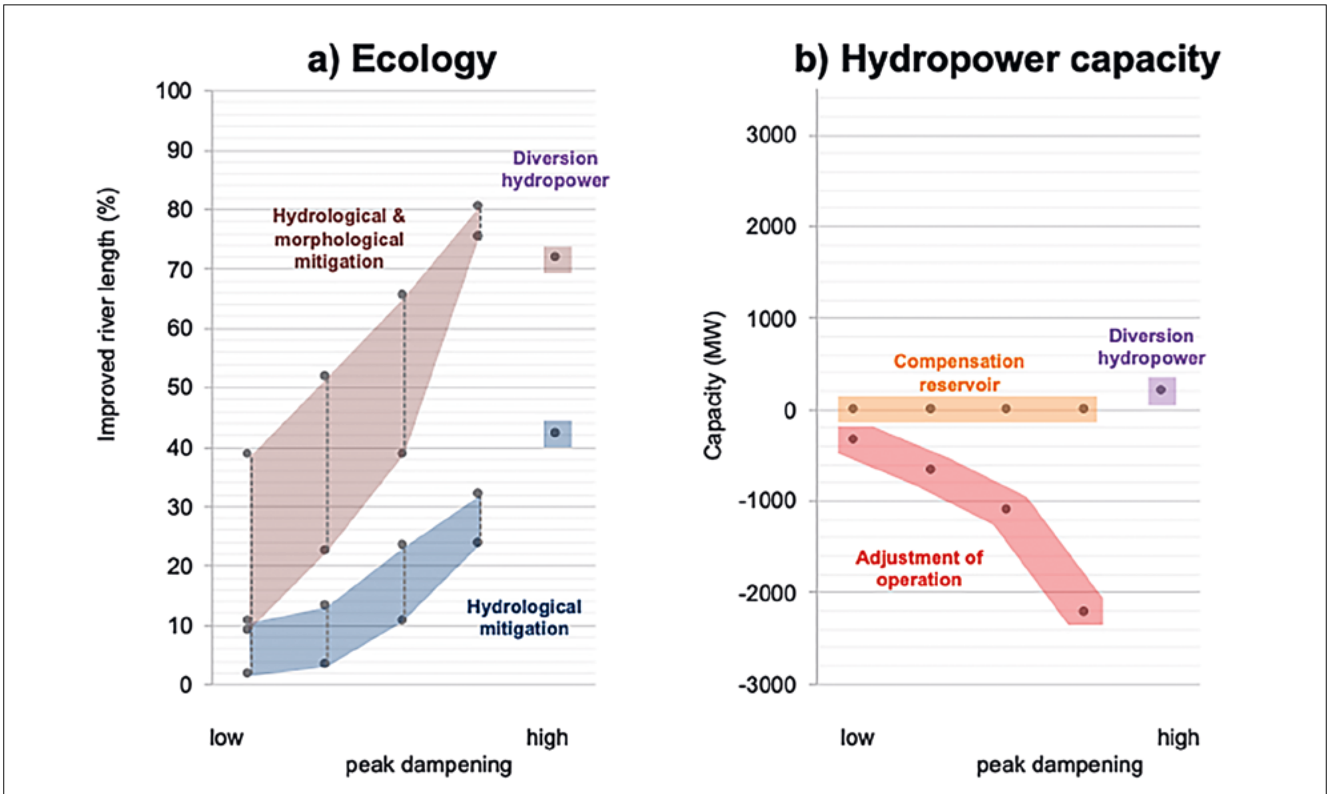

Figure 1: Ecological improvements (a) compared with impacts on HP use (exemplified by capacity) based on peak dampening scenarios from low to high by implementing mitigation measures, i.e. compensation reservoirs, diversion HP or adjustments of HP operation including morphological improvements (cumulated representation of analyzed case studies, adapted from Greimel et al. 2017).

Figure 2: *The 9.5 km long “New Traisen” was created by the 30 Mio Euro LIFE+ Traisen project financed by VERBUND Hydro Power with co-funding by EU and other donors, credits: VERBUND Hydro Power.*

impact downstream flows. Two examples given below show that even in those cases ecologically effective and technical/ economic feasible improvements can be achieved.

Case study mitigating hydro-peaking in Austria

HP plays an important role in balancing electricity production/consumption by storing water in reservoirs and delivering electricity when needed. As a consequence, rivers receive less (during storage) or more (during HP operation) water than naturally, a phenomenon called hydropeaking. Such rivers are exposed to rapid peak flows and dewatering events, often happening several times a day. Main consequences for river organisms could be increased drift during peak flows and stranding during dewatering. In Austria, more than 800 km of rivers are classified as HMWB due to hydropeaking. In HMWB, the objective is to achieve the “Good Ecological Potential” which is - in simple words - the status that can be achieved when implementing effective and technically feasible mitigation measures that do not significantly impact hydropower use or the wider environment (WFD). Within the frame of a number of research projects a new methodology was developed to monitor and assess the ecological consequences of mitigation measures and potential impacts on HP use such as installation of compensation reservoirs, altered HP operation and diversion HP (see Halleraker et al. (2016) for more details on mitigation options). The challenge was to define quantitative criteria and scenarios for the expected ecological improvements that could be directly related to the expected impacts on HP use. The latter was assessed by estimating the economic losses due to reduced HP production including impacts on energy safety and consequences for climate change (additional CO_2 emissions by substituting HP with fossil energy production). Based on a number of case studies analyzed in close cooperation among scientific institutions, HP companies and governmental administration the following main conclusions could be drawn: Highest ecological effects can be achieved by combining peak dampening or diversion HP with morphological improvements *(fig. 1a)*. While adjustments of HP operation results in significant impacts on HP use (loss of capacity) at already low peak dampening levels, compensation reservoirs and diversion HP do not impact HP use (fig. 1b), However, the latter may cause disproportionate costs or might be technically not feasible in specific cases. Based on these findings case-specific feasibility studies are now developed for affected river sections, ecological monitoring methods are adjusted to better assess mitigation effects and first implementation projects are scientifically monitored. The first mitigation project in form of a combination of a compensation reservoir and diversion HP is currently build at the river Inn and will be subject to scientific

Figure 3: *Danube salmon (Hucho hucho) caught on 17.10.2018 in the "New Traisen" created by the "LIFE+ project Traisen", credits: T. Kaufmann.*

only for fishes of the Traisen but also of the Danube. Gravel spawners such as nase *(Chondrostoma nasus)* and barbel *(Barbus barbus)* use the Traisen for reproduction. The species richness increased from 20 to more than 30 species. The "New Traisen" provides habitat for rare, endemic and endangered species such as zingel *(Zingel zingel)* and streber *(Zingel streber)*. The newly created river course can be seen as a compensation measure for the lost fluvial Danube habitats and significantly contributes to achieving the "Good Ecological Potential" in the Danube HP cascade.

monitoring and evaluation in the next years (www.gemeinschaftskraftwerk-inn.com). Results of the ongoing research project ÖkoReSch (forschung.boku.ac.at) will feed into an upcoming national guideline supporting hydropeaking mitigation in Austria.

Case study habitat restoration at Traisen river

During the implementation of the Danube HP Altenwörth in the mid 1970ies the mouth of the tributary Traisen was channelized, disconnected from the Danube and dislocated downstream to the tailwater of the HP Altenwörth. The aim of the "LIFE+ project Traisen" was to re-connect the Traisen to the Danube, re-create a natural river course of 9.5 km length and to improve terrestrial and aquatic floodplain habitats *(fig. 2)*. This 30 Mio € project was financed by VERBUND Hydro Power with co-funding by the EU and other donors and was implemented in 2012-2016. Endangered species such as the Danube salmon *(Hucho hucho)* and sterlet *(Acipenser ruthenus)* were stocked and the recovery process of the fish stocks were monitored within scientific projects (fig. 3). The ecological status of the "New Traisen" improved from pre-project "poor/moderate" to post-project "high" ecological status based on the fish fauna (fig. 4). The "New Traisen" now serves as spawning and nursery habitat not

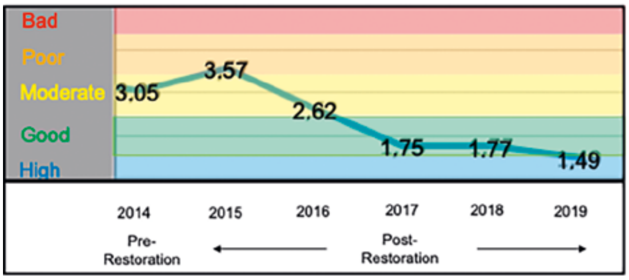

Figure 4: *Improvement of the fish ecological status of the Traisen. Classification according to Fish Index Austria / WFD.*

Conclusions

HP plays an important role in providing renewable energy but at the same time may cause significant impacts on aquatic ecosystems. Nowadays, a number of mitigation technologies are available or under development that can effectively improve the ecological conditions. Even in case of HMWB ecological improvements can be achieved without impacting HP use if mitigation measures are thoroughly planned and sufficient (co-)funding is provided. Recent experiences gained in Austria and exemplified here prove that the objectives of the WFD, i.e. to achieve the "Good Ecological Status/Potential" can be achieved if the required scientific foundation is sufficiently elaborated, solutions are developed together with stakeholders and adequate funding instruments are available.

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News and Notes

Obituary Acad. Prof. Dr. Marian Traian Gomoiu (1936 – 2021)

Photo: m.ziuaconstanta.ro

With great sadness, we announce that the academician Marian Traian Gomoiu, former Romanian National Coordinator of the International Association for Danube Research (2004 – 2016), has passed away.

Biologist and oceanographer, member of the Romanian Academy of Sciences, he was a key founder of the modern marine ecology in Romania, fostering research of Black Sea benthic biocenoses, eutrophication and invasive alien species, including scuba-diving observations. His scientific career started in 1959, as researcher at the Oceanography Lab. of the Institute of Biological Sciences, Romanian Academy. In 1970, this lab became part of the Romanian Marine Research Institute Constanta (currently, the National Institute for Marine Research and Development "Grigore Antipa" – NIMRD), where he carried out numerous projects and attended specialization internships at different international organizations.

In 1973, under the coordination of academician M. Băcescu, he received his PhD in biology at the Institute of Biological Sciences, Bucharest, with the thesis entitled "Contributions to the knowledge of the ecology of psamobiont molluscs from the sandy submerged beaches of the Romanian Black Sea coast", opening the path for a new field of marine scientific research in Romania.

The specialized fields in which he excelled throughout his scientific activity were marine ecology and the study of biodiversity, making important contributions to the dynamics of all benthic biocenoses. In the field of benthic marine biology, he was among the first to make direct observations, by diving, on benthic marine biocenoses.

In 1990 he joined the initiative group that founded the "Ovidius" University of Constanta (Romania), working from the beginning in the Faculty of Biology. Since 1990, he has been a doctoral supervisor in "Ecology" at this university.

He was also the first governor of the Danube Delta Biosphere Reserve (1990 – 1993), playing a major role in setting up the administrative organization and governance structure of this protected area. Since 1994, he was deputy director, and later counsellor at the National Institute for Research and Development on Marine Geology and Geo-ecology – GEOECOMAR, where he worked until 2016.

His bibliographic list includes over 200 titles (published in specialized journals in Romania, USA, Great Britain, the former Soviet Union and later in different states of the European Union). The most important scientific papers are those included in the series of five volumes of Marine Ecology, published between 1965 and 1976 under the auspices of the Romanian Academy, reference volumes for marine scientific research in the Black Sea basin.

His scientific recognition is also acknowledged by his presence as deputy editor of "Researches Marines / Cercetari marine" journal and as member in several editorial boards of specialized scientific publications: "Romanian Journal of Animal Biology" of the Romanian Academy, "GeoEcoMarina", "Scientific Annals of Ovidius University - Biology Series Ecology."

He was a member of several scientific structures at national and international level: chairman of the Division of Environmental Biology within the National Committee of International Union of Biological Sciences (IUBS); chairman of the Government Commission "Techirghiol"; member of the National Commission for Biosafety; Rapporteur for the Black Sea of the Benthos Committee - Mediterranean Science Commission - CIESM; expert in the Commission for Environment, Ecological Balance and Water Management of the Government of Romania; member of the International Union of Biological Sciences (IUBS) - National Commission of the Romanian Academy; member of the Commission of Hydrology and Aquatic Ecology of the Romanian Academy; chairman of the Academy's Oceanography Commission; member of the Scientific Council of the Institute of Biology of the Romanian Academy; member of the Scientific Council of MEDIFAUNE (a biological data bank on the Mediterranean marine fauna - France); member of the Malacological Society of Italy; member of the International Association for the Study of Meiobenthos; member of the Scientific Council of the Tulcea Eco-Museum Research Institute; member of the Scientific Council of the Danube Delta Biosphere Reserve; member of the National Commission of the Coastal Area; president of the Oceanology and Limnology Commission of the Romanian Academy. He was also a member of national and international professional organizations: Society of Biological Sciences; Association of Romanian Scientists; Romanian Ornithological Society; Romanian Naval League; Romanian Society of Ecology; Romanian Society of Limnology; Romanian Society of Ichthyology.

Through the death of the academician professor Marian Traian Gomoiu, the marine biology loses a representative of great value and a remarkable personality. We are very thankful for his comprehensive work, for the immense contribution to nature conservation in Romania and beyond, and also for the numerous generations he formed during the past decades.

Tania Zaharia,National Institute for
Marine Research and Development
"Grigore Antipa" (NIMRD) Constanta

Obituary Prof. Dr. Roumen K. Kalchev (1951 – 2021)

Photo: Personal archive m.ziuaconstanta.ro

With great sadness we share the news that the highly respected and eminent Bulgarian hydrobiologist and IAD board member Prof. Dr. Roumen Kirilov Kalchev has passed away from COVID19 on 12th March 2021.

Professor Dr. Roumen Kalchev was born on 20th November 1951 in Kubrat Town, Bulgaria. In 1979, he graduated from the University of Rostock, Germany, major in Biology: Freshwater and Marine Hydrobiology. In 1984, he successfully defended his PhD dissertation on the topic "Fluorescence characteristics of some algal species and possibilities for their application for studying primary production of fresh waters" at "Taras Chevchenko" University and the Institute of Plant Physiology of the National Academy of Sciences of Ukraine in Kiev. Immediately after his defence he was appointed at the Institute of Zoology, Bulgarian Academy of Sciences (IZ-BAS), as an Assistant Professor (1984) and later as an Associate Professor (2002). In 2015, he received the rank of Professor at the Institute of Biodiversity and Ecosystem Research, BAS (IBER-BAS). Professor Kalchev was the head of the Phytoplankton Research Group (RG) and Hydrobiology Department at IZ-BAS. Since 2010 he was the head of the Lenthic Ecosystem RG and Section of Biodiversity and Processes in Freshwater Ecosystems at IBER-BAS.

The main research efforts of Prof. Roumen Kalchev focused on the composition and functioning of phytoplankton, the photosynthetic pigments, and measurement of primary production by different methods, such as variation in oxygen concentration, carbon radioactive isotopes and fluorescence technique. Professor Kalchev has revealed significant relationships between chlorophyll-a and the phytoplankton parameters (taxonomic and functional groups, algal size, abundance, biovolume, etc.) in water bodies of Bulgaria and the Danube River basin. Further, his research interests extended to aquatic chemistry and nutrient cycles, especially the phosphorus and nitrogen limitation of phytoplankton growth; pelagic trophic relationships between solar energy, nutrients, bacterio-, phyto- and zooplankton and assessment of the trophic status and water quality gradients in stagnant water bodies. His recent studies dealt with impact of the invasive alien species, in particular the mussel species of the genus *Dreissena,* on physical and chemical parameters of water and bacterio-, phyto- and zooplankton in infested reservoirs in Bulgaria. His original scientific and applied contributions helped to successfully solve problems in the conservation and sustainable use of biological resources in standing natural and artificial water bodies, as well as in the restoration and protection of wetlands.

Significant parts of Prof. Kalchev's research-, project-, expert- and organisational activities were connected to the Danube River and the adjacent wetlands. Professor Kalchev developed successful scientific collaboration on relevant topics with colleagues from other Danube countries, being an initiator and national leader in several bilateral projects: "Impact of Iron Gates reservoirs hydraulic river structure, tributaries and adjacent wetlands on ecological interactions, water quality and biodiversity in the Lower Danube" (2005–2006) (Bulgaria – Romania); "BioWetMan: A science based approach to understand biodiversity driven functions and services for improving wetland management" (2008–2009) (Bulgaria – Austria); "Comparison between wetland – Danube River systems of Hungary and Bulgaria related to their biodiversity, functioning, services, management and nature conservation" (2013–2015) (Bulgaria – Hungary); and "The significance of habitat diversity in Danubian wetlands of Hungary and Bulgaria for biodiversity, biological invasion, functioning, management and services of aquatic ecosystems" (2016–2018) (Bulgaria – Hungary). Since 2010, Prof. Kalchev was the country representative of Bulgaria in the International Association for Danube Research (IAD). He was an active member of IAD, contributing to several expert groups (EG), mostly to Water Quality EG, Biotic Processes EG, Phytoplankton / Phytobenthos EG, Invasive Alien Species EG, and others. Professor Kalchev was co-founder of the Danube River Invasive Alien Species Network (DIAS) (2014) and participated actively in all DIAS meetings and activities. He participated in eight of the IAD Scientific conferences and was a chair of the Organising and Scientific committees of the 40th IAD Conference "The Danube and Black Sea Region – Unique Environment and Human Well Being Under Conditions of Global Changes" held from 17–20 June 2014 in Sofia, Bulgaria.

Professor Roumen Kalchev is an author and co-author of more than 150 scientific publications, including a textbook on Ecotoxicology. He was involved in teaching and practical training of students at the Biological Faculty of Sofia University. For 12 years he led practical courses on Hydrobiology and advised two PhD and four MSc students.

With passing of Prof. Dr. Roumen Kalchev we have lost a distinguished scientist and colleage, an active and dedicated member of IAD, and a good friend!

We express our deepest sympathies to his family, friends and colleagues!

Teodora Trichkova
Bulgarian Academy of Sciences

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Hydrological catchment of the River Danube

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