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WORLD FISH MIGRATION FOUNDATION

Institute of Fisheries Management

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A1 Implementing European Biodiversity Targets and EU policies for free-flowing rivers

River continuity restoration policies and freshwater ecosystem restoration

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The EU Biodiversity Strategy aims on freshwater ecosystem restoration by implementing WFD objectives to be met by 2027. Moreover, the Nature Restoration Law wants to make the restoration of 25.000 km free flowing rivers by 2030 a binding target. For river restoration there should be more attention to geo-hydro-morphological processes, water flows, sediments and nutrients transport and climate change adaptation. National restoration plans should be made. River fragmentation and barriers should be inventoried, the area to be restored should be quantified, river continuity restoration measures should be planned, like adding a fish pass, constructing a barrier by-pass channel, barrier removal, adapted management of the environmental flow and lowering the barrier. The national river continuity policies should be (made) suitable for this approach concerning policy background and design, policy effectiveness, restoration tools, stakeholder involvement, financing and monitoring and evaluation of the restoration projects and the policy itself. A study on 10 national policies across Europe was made. In depth analyses were done and interviews were held with policymakers, planners and implementers.

Towards a free(er) flowing Netherlands

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River systems in Europe are highly fragmented due to different types of barriers such as dams, barrages and locks. This has a significant impact on river ecosystems and associated biodiversity. According to the latest Living Planet index, migratory fish stocks in European rivers have declined by 93%. The main reason is the loss of connectivity, but there are also other negative effects. For example, a lack of sediment transport and water quality problems. But times are changing. The EU Biodiversity Strategy for 2030 includes the target to make at least 25000 km of rivers free flowing again by 2030. Not only to restore connectivity and improve fish migration, but also to reduce safety concerns, improve water quality, restore natural sedimentation and erosion processes and biodiversity. What does this mean for the Netherlands, a delta country which is part of 4 international river basins? How can we contribute to this target? Where are opportunities, and what are important challenges? The World Fish Migration Foundation has been working together with 12 Dutch water authorities to map the Dutch rivers according to their free flowing characteristics. This map supports the identification of potential biodiversity hotspots, and can be used to start joint discussions about how, where and with whom the Netherlands can contribute to the realization of the EU target. Even though we have been working on river restoration since the 1990s, most of the Dutch waters (>90%) lack a free flowing character. This means that there is plenty of room for improvement!

Reviving Europe's rivers: Seven challenges in the implementation of the Nature Restoration Law to restore free-flowing rivers

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River systems in Europe are highly fragmented due to different types of barriers such as dams, barrages and locks. This has a significant impact on river ecosystems and associated biodiversity. According to the latest Living Planet index, migratory fish stocks in European rivers have declined by 93%. The main reason is the loss of connectivity, but there are also other negative effects. For example, a lack of sediment transport and water quality problems. But times are changing. The EU Biodiversity Strategy for 2030 includes the target to make at least 25000 km of rivers free flowing again by 2030. Not only to restore connectivity and improve fish migration, but also to reduce safety concerns, improve water quality, restore natural sedimentation and erosion processes and biodiversity. What does this mean for the Netherlands, a delta country which is part of 4 international river basins? How can we contribute to this target? Where are opportunities, and what are important challenges? The World Fish Migration Foundation has been working together with 12 Dutch water authorities to map the Dutch rivers according to their free flowing characteristics. This map supports the identification of potential biodiversity hotspots, and can be used to start joint discussions about how, where and with whom the Netherlands can contribute to the realization of the EU target. Even though we have been working on river restoration since the 1990s, most of the Dutch waters (>90%) lack a free flowing character. This means that there is plenty of room for improvement!

B1 Ecology and hydromorphology of free-flowing rivers

Over 200,000 kilometers of free-flowing river habitat in Europe is altered due to impoundments

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European rivers are disconnected by more than one million man-made barriers that physically limit aquatic species migration and contribute to modification of freshwater habitats. Here, a Conceptual Habitat Alteration Model for Ponding is developed to aid in evaluating the effects of impoundments on fish habitats. Fish communities present in rivers with low human impact and their broad environmental settings enable classification of European rivers into 15 macrohabitat types. These classifications, together with the estimated fish sensitivity to alteration of their habitat are used for assessing the impacts of six main barrier types (dams, weirs, sluices, culverts, fords, and ramps). Our results indicate that over 200,000 km or 10% of previously free-flowing river habitat has been altered due to impoundments. Although they appear less frequently, dams, weirs and sluices cause much more habitat alteration than the other types. Their impact is regionally diverse, which is a function of barrier height, type and density, as well as biogeographical location. This work allows us to foresee what potential environmental gain or loss can be expected with planned barrier management actions in rivers, and to prioritize management actions.

The effects of the German-Polish expansion of the Odra River on nutrient retention and water quality

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Existing plans to enhance the Oder River for commercial navigation by rehabilitating existing and constructing new groynes face significant opposition from environmental associations and authorities. The presence of groynes alter flow conditions, water residence time, riverbed structure and habitats, consequently impacting internal material processes and water quality. This study investigates the groyne fields' influence on nutrient retention, an area with limited prior research. Based on a literature study and information from published construction plans, the retention module in the MONERIS model was further developed. The combined modeling of discharges, nutrient emissions, and expected morphological and hydrological changes allows to estimate the impact of newly constructed groyne fields on in-water retention, concentrations, and loads. The results reveal that the increased retention in groyne fields is counteracted by reduced retention in the Odra's navigation channel, with minimal resulting total changes in in-water retention and loads. However, the geometry of the groyne fields affects these outcomes. Additionally, nutrient retention in groyne fields depends on input loads, groyne field flow conditions, and water temperature. While the results align with previous studies in other rivers, a calibration and validation could not be conducted due to lacking data. This combined approach offers a vital foundation for assessing effects of groynes under varying hydro-climatic and nutrient emission scenarios. Furthermore, it supports a realistic assessment of emission reduction needs and management options to meet HELCOM's water quality goals for 2021 and restoring eutrophied and degraded riverscapes.

Invisible actors: Thermal responses to low head impounding structures – Identification, quantification, prioritization, and mitigation

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Low head impounding structures alter the natural processes of rivers through a modification of key parameters. The modified parameters have the potential to extend the influence of the obstacle beyond its immediate environment. Temperature is one such critical parameter that determines both the biotic and abiotic elements of aquatic habitats. In the context of climate change, the impacts of altered thermal regimes are set to be exacerbated rather than ameliorated. Temperatures were recorded at weirs and control sites during five summer periods in two large rivers systems on the east coast of Ireland. Significant trends in upstream and downstream temperature variation were observed. Additionally, temperature ranges were greater within weir impoundments compared to a free-flowing location. The impoundments also had a stronger association with temperatures above the upper thermal range for brown trout growth when compared to a control site. Explanatory factors such as impoundment retention time, impoundment depth, height of structure, and riparian canopy cover were also investigated. The higher water temperatures extending behind and downstream of weirs may function as a secondary, invisible, barrier to diadromous fish migration. There are approximately 2,830 weirs in the Irish river network. Mitigation strategies must see beyond fish passage to include the broader hydromorphological health of an extended reach. The identification, quantification, prioritization, and mitigation of "Red Flag" temperature structures must be seen as a priority to protect cold water fish species in a warming climate.

How damming contributes to global warming: Learning from the free-flowing Upper Neretva River in Bosnia-Herzegovina

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The Upper Neretva River is a uniquely intact river network in Bosnia-Herzegovina threatened by several hydropower projects. Within the Neretva Science Week 2022, we studied emissions of the greenhouse gases CO2 and CH4 in a 50 km river section with natural flow conditions. We combined point measurements of dissolved gas concentrations with modeled network-wide gas exchange velocities between water and atmosphere. From this, we estimated gas emissions and uncovered their spatial heterogeneity and their controls. CO2-oversaturation was widespread due to frequent groundwater input and supported high emissions in turbulent river reaches. In contrast, CH4 concentrations were more variable over space due to localized production of CH4 in slow-flowing river habitats. CH4-emission was extremely high in a turbulent section downstream of an exceptionally large pool favoring CH4 production. Overall, we affirm that current greenhouse gas emissions of this river section in its near-natural state are limited, as the river mostly emits CO2 at low rates. However, riverine habitat features play an important role in the production of CH4, which is subsequently rapidly outgassed to the atmosphere. The same mechanism transforms man-made reservoirs into sizeable sources of CH4: Artificially slowly or even standing water, fine sediment deposition and higher water temperatures support the deep-water production of CH4 in reservoirs, which is then rapidly outgassed after the turbines. In fact, from a scientific standpoint, stopping hydropower development on the Neretva (and elsewhere) is an act of responsibility given its contribution to global warming.

C1 River restoration projects

Restoring the Westerwoldse Aa from sea to source: 30 years of improving water quality, connectivity and habitat diversity for fish

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Irreversible modifications to ecosystems limit the possibility to meet restoration targets based on historic reference. The Westerwoldse Aa stream basin (The Netherlands) is such a so-called novel ecosystem. The stream basin has lost peatlands, experienced pollution as well as canalization over different periods dating back to the 1400s. From 1990 onwards a diverse range of measures were implemented to improve water quality, in-stream habitat quality, and connectivity across the entire stream basin. We evaluated the combined effect and development over time. Water quality gradually improved after changes in legislation regarding wastewater treatment. Total N decreased below threshold concentrations of 2.5 mg L-1 for the first time in 2017 which is 47 years after the first efforts were initiated to reduce nutrient load of the surface waters. Longitudinal connectivity has improved through constructing 34 fish passages of different types depending on local conditions. Due to re-meandering the total stream length from sea to source increased from 69.8 to 80.4 km. However, thus far the fish community remains dominated by eurytopic species. These species did never disappear entirely while rheophilic and diadromous species became locally extinct and require more time to recolonize the area. Moreover, creating free-flowing conditions through remeandering and barrier removal is a more recent enterprise and therefore the reappearance of formerly lost in-stream habitats is only just starting. Hence, continued evaluation is essential before all the restoration efforts can be thoroughly evaluated.

Rollin'Rivers – People, knowledge and action to enhance river restoration in Portugal

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River ecosystems are between the most biodiverse on our planet and the most intensively affected by human activity. While, in an effort towards climate action, Europe compromised to restore river ecosystems and improve their connectivity, Portuguese rivers are highly threatened by 13000 barriers to river connectivity, loss of native and spread of invasive species, pollution, and lack of effective legal protection. Meanwhile, governmental programmes promote new dams throughout the country, barriers to river connectivity are yet to map, National Programmes for River Restoration and for Barrier Removal do not exist, and most municipalities are not aware of the good practices for river rehabilitation. Here, we present the project "Rollin'Rivers - People, Knowledge and Action to Enhance River Restoration in Portugal". This project, integrating population, municipalities, governmental water management entities, universities, river restoration specialists and environmental media agencies, enables both a behavioural change and the long-term conservation and restoration of Portuguese freshwater ecosystems, contributing to climate action. Using the Alviela sub-basin as main study-site, and a methodology replicable at the basin and national scales, we will map and characterize the barriers to river connectivity, to prioritize their removal based on ecological social and economic criteria. Alongside, we will promote a public participated process and river rehabilitation actions, including removal of barriers to river connectivity. Finally, lobby and advocacy actions will be conducted from the local to the regional and national levels, in line with a communication strategy promoting river conservation and restoration.

Natural fluvial processes as a tool of river restoration (example of Polish Surface Waters Restoration Programme)

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Well-planned river restoration is rather not artificial river-shaping in more natural way, but initializing fluvial processes which will restore and maintain better fluvial morphology of the river bed. In many cases, spontanic fluvial processes, even in altered river, may bring significant progress towards restoration. In particular, in high-energy gravel submontane rivers, high flow and floods episodes may significantly improve bed and banks morphology and remove obsolete embankments: although such results are commonly considered as "flood damages", they also may be accepted as restoration progress. In lowland forest rivers, the spontanic processes of trees death and woody debris delivery may be followed by significant diversification of channel morphology and restoration basic morphological and ecological features of river ecosystem. On the other hand, in some lowland river the flow energy is not sufficient to initiate spontanic river bed restoration. Also strong, concrete barriers usually should not be removed this way. In Polish National Surface Waters Restoration Programme (developed 92021) it was estimated that ca 90% of Polish river water bodies need some restoration for achieving environmental objectives, nevertheless for ca half of them the restoration is achievable by spontanic fluvial processes, with only soft interventions initializing them.

Structural measures for the near-natural development of the Neckar in Mannheim

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The Neckar is the fifth largest tributary of the Rhine and the twelfth largest river in Germany. The last free-flowing section is located near Mannheim. In contrast to the further, upstream course, there are no dams here and no water abstraction for hydropower utilization. In order to improve the hydromorphological characteristics, measures were implemented to face the European Water Framework Directive. A large restoration measure was carried out in the area of conflict between hydropower operation, flood protection, inland navigation and various uses of the foreland. To meet these requirements, local objectives for planning and execution were defined and the measures were optimized with the help of hydronumerical investigations. As part of the measure, the banks were cleared of riprap for more than 3 km on both banks, the banks were flattened, the stream meandered slightly and sidewaters were created. Extensive work had to be carried out to remove explosive ordnance above and below the water. About 200,000 m³ of soil has been moved. The construction work was preceded by measures to protect flora and fauna. The work has started August 2022 and will be completed in fall 2023. An increase in the fish and bird population is already evident, and new species have established. Whilst the construction work, the local beaver population was able to further establish itself and reproduce. For the people of Mannheim, an attractive, near-natural bank with access to the water has been created, increasing the connection with the Neckar and the awareness of natural waters.

Ecostreams: Holistic approach to restoring aquatic habitats in Northern Sweden

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The Ecostreams project aim to rejuvenate diverse habitats catering to an extensive range of aquatic species. Not only those stated in the species and habitats directive, but also other important species tied to the aquatic flora and fauna. The freshwater conservation team at the County Administrative Board of Västerbotten, has a holistic, long-term approach and wish to continue applying for more and larger projects in the future. Northern Sweden faces a pressing need for the restoration of its rivers and tributaries due to historical utilization for timber floating, resulting in substantial alterations. These watercourses suffer from structural clearance, channelization, fragmentation, damming, and road crossings with potentially obstructing culverts, severely hindering species migration and dispersion. This affects not only the target species, but also other species – including us humans. In the backdrop of a changing climate, scientists predict amplified and erratic weather patterns, marked by heightened temperatures and intense rainfalls leading to droughts and floods. The gravity of these climatic shifts is magnified in the absence of functional, resilient aquatic ecosystems. By restoring the affected watercourses, the current slows down, the water transports through a longer path in the landscape as meandering is restored. The lateral connectivity between water and land regains its function and floodplains are being occasionally flooded and can buffer water flows. In our oral session, we will talk about stream restoration efforts within the context of northern Sweden. How our northern Swedish waterbodies have been altered and used through history and what actions needed to restore functions.

D1 Conservation of Danube River basin

Prioritizing conservation and monitoring areas in the Danube River basin: Insights from the DANUBE4all project

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The Danube River basin currently lacks a comprehensive action plan for restoring its freshwater and transitional water ecosystems, despite some efforts to address continuum disruptions in upstream regions. The DANUBE4all project aims to address these challenges by identifying, selecting, and recommending implementation measures to increase the extent of free-flowing rivers throughout the entire basin. One of the specific objectives of the project involves identifying suitable habitats for both protected and invasive species, prioritizing conservation actions. To accomplish this, we initially modeled the habitat suitability of the fish species that inhabit the Danube basin. Fishes were chosen because they are good indicators for longitudinal connectivity. This modeling process involved spatially explicit species distribution models, which were trained using environmental data and information on species occurrences. Following the habitat suitability modeling, we conducted a spatial conservation planning analysis. This analysis aimed to pinpoint regions across the Danube River basin that are of high priority for future conservation and monitoring efforts. Priority areas were identified based on the presence of suitable habitats for fish species and the facilitation of longitudinal connectivity within the river system.

Comprehensive efforts towards improvement of the Danube inland delta water regime

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Within six LIFE projects (LIFE07NAT/SK/000707, LIFE08NAT/SK/000239, LIFE10NAT/SK/000080, LIFE12NAT/SK/001137, LIFE14NAT/SK/001306, LIFE17NAT/SK/000621) we worked on complex improvement of the Danube inland delta water regime. This extensive wetland area and important fresh water reservoir situated south-east from Bratislava, once an anabranching river system, was heavily altered by human interventions, including the Gabčíkovo hydropower plant construction. The inland delta ended up separated from the old Danube River bed, clogged with sediments, depending on one artificially built water supply. During more than two decades, Operational Manual promising regular simulated floods to compensate the disturbed hydrological regime was not being followed. Water scarcity failed to supply underground water reservoir, ensure humidity of floodplain forest soils or flush fine sediments resulting in clogging. We succeeded to start off again regular floods (yearly; spring and summer) with help of huge petitioning action covering 11,603 signatures forwarded to Minister of Environment and following numerous negotiations with relevant authorities, step by step achieving higher maximum discharge, longer culmination and earlier onset of floods beneficial for amphibian reproduction. The Danube inland delta is divided by transversal weirs, constructed to retain water in the system but minimizing flow dynamics and creating migration barriers at the same time. Based on complex expert studies aimed at improving lateral and longitudinal connectivity, concrete conservation measures were implemented here: 155.95 ha of wetlands restored by digging of channels, 24.788 km of river branches restored by removal of barriers and reconstruction of culverts and 225 m of steep river banks created for nesting birds by dredging.

Connectivity assessment for fish in the Danube River basin

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Free-flowing rivers only represent a fragment of the European river network as they had been regulated historically for various reasons in the past. As one of the European Lighthouse initiatives that targets to improve the environment for both nature and society, the Danube4All project aims to reconnect rivers, floodplains and delta across the Danube River Basin (DRB). Part of the project tasks is to assess multi-dimensional connectivity for the Danube and its main tributaries, and the presented work focuses on longitudinal connectivity for biota. There are more than 60 large transversal barriers, such as dams, found on the river Danube and many hundred similar types are located on its main tributaries. Each of them has an impact on the free movement of fish species, that ranges from complete blockage to insignificant level. Upon gathering the barrier database from the DRB, barriers were classified individually using local expertise by their impact on both upstream and downstream migratory fish. Using 'riverconn' as a tool, that has been developed as an R package, connectivity indices were calculated for the river basin assessment for fish. Results show the importance of sufficient passability status of key barriers across the river basin to achieve good restoration goals for fish. In addition, by demonstrating the applicability of this evaluation tool on such a large river basin, the presented work also concludes the necessity of local knowledge and data availability for transboundary river restoration projects.

NaturaSat Wetland project – A novel tool for riparian vegetation monitoring after river branch system restoration

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Riparian vegetation – alluvial meadows, natural eutrophic lakes, and muddy banks – are among the most threatened habitats in Slovakia due to river regulation, water regime changes, and pressure of invasive species. Many of these habitats along the Danube River are degraded, and their quality is still decreasing. Water regime, especially the timing and duration of floodings, is crucial for this habitat's existence. Several LIFE projects were implemented in the Danube inland delta to improve this status. Restoration of the water regime by re-connecting river branches and managing simulated floods has begun. Vegetation monitoring on permanent plots was established on the project sites before and after management activities. Due to the specific characteristics of habitats, their revitalization is a complicated process depending on deep scientific knowledge. Especially for muddy banks habitats and water habitats in oxbows, standard monitoring methods fell short in the assessment of revitalization success. Therefore, novel remote-sensing tools implemented in NaturaSat Wetlands software were adopted. The software was used for the segmentation of habitat areas during the time when the water level was lowest, and most of the existing gravel and muddy banks were bare, and monitoring continued monthly to obtain the time series of habitat extension. The same time-series was used for natural eutrophic lakes, where it is necessary to keep water for the whole vegetation season. The first results showed the vast potential of remote-sensing methods, as well as revitalization success within five years of monitoring. The contribution was supported by grants LIFE14NAT/SK/001306, LIFE18 NAT/AU/000733 and VEGA2/0097/22.

Biodiversity data quality flagging checks for distribution models using species ecological and tolerance limits

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The reliability and effectiveness of species distribution models (SDMs) depends on the quality of species occurrence records used to develop the models. Given the enormous amount of species occurrence records continuously archived in freely accessible online repositories (such as GBIF) coming from a variety of sources, the resulting quality of data is heterogeneous which makes data cleaning indispensable. Taxonomic and spatio-temporal quality checks are widely adopted to flag and discard occurrence records before developing SDMs; however, the principle of species ecological tolerances and limits is often neglected. This may lead to the consideration of occurrence records (i.e., points) outside the species ecological range, which in turn may affect the model reliability and management strategies such as prioritization or restoration efforts developed thereafter. In this study, we apply different data cleaning protocols to serially flag and discard occurrence records outside the species ecological or geographic range. Subsequently, we develop SDMs, and apply threshold-dependent and independent assessment metrics including sensitivity, specificity, area under the curve, true skill statistics, balanced accuracy, and misclassification rate to compare model performance using different data cleaning protocols. We test the criteria on different fish species from the Danube River basin including widely distributed fish species (Squalius cephalus, Salmo trutta and Chrondrostoma nasus); endemic species (Hucho hucho), and rare species (Gymnocephalus baloni). The presented approach will help to develop better predictions of species distributions and subsequently derived recommendations for conservation and restoration measures.

E1 Cultural and socio-economic aspects of dam removal

People love their weirs – Moving goalposts in a dam removal project

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The River Sieg is designated as a Salmon restoration river in the German States of North Rhine-Westphalia and Rhineland-Palatinate. Therefore, there is a high priority to remove barriers or restore fish passage as part of the EU Water Framework Directive implementation. The State of Rhineland-Palatinate is seeking to remove Euteneuen Weir. The existing 40-m wide two-section weir with a head of 3.53 m was formerly used for hydropower generation for over a century. Although (restoration of) river continuity is legally required, the removal project implementation has so far been accompanied by fierce resistance from various stakeholders, each with different interests. As a result, the project has become extremely controversial and highly political, leading to a delay in implementation and an excessive level of public relations effort and legal dispute. Further, unforeseeable additional project objectives had to be taken into account to obtain a licensable and widely acceptable solution. These included the conservation of a hardwood swamp forest upstream which has developed because of the river impoundment. Ultimately, these have led to a different solution than initially envisaged and additional costs for implementation. The presentation will (a) outline the original and additional project objectives, (b) highlight the conflict between hydropower use, anthropogenically altered but protected riverine environments and free-flowing rivers, and (c) illustrate how the project can/will be realized despite public opposition by means of stakeholder interaction and adjusting the projects' goal(post)s.

The adventure of implementing a barrier removal project – A socio-cultural perspective

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River ecosystems are key to sustain Earth's biodiversity and carbon and nutrient cycles, but are severely affected by human-induced changes. Barriers are one of these impacts, affecting the hydromorphological regimen, sediment transport, and structure and functioning of biological communities. Consequently, in recent years, attention has been focused on barrier removal as a restoration tool. While barrier removal is gaining credibility among managers and scientists as a viable option for restoring river ecosystems, more and more demolition projects are facing public opposition. The reasons for this opposition are many and varied, but often are based on the perception of local people, who like the stagnant waters and the "waterfall", and often use cultural, and heritage values as a way to prevent their removal. Here, we present a case study of the different social obstacles that have been arising during the implementation of river restoration actions, based on the demolition of 10 barriers along the Deba River basin, in Gipuzkoa. In the current context of global change, it is essential to promote restoration actions that contribute to increasing the resilience of river ecosystems and mitigating its effects. However, the complexity of the social dimension requires that such restoration actions be adapted locally. Only in this way can the removal of river barriers allow the renewal of degraded river ecosystems, gain social acceptance, and enhance the cultural and historical value of an area.

Dam removal in Austria – How to move from pilot projects to standard procedure?

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The transboundary river basin management plan for the Danube River records about 1,000 dams in large rivers. Small Austria has the largest share of barriers. Including small catchments, the inventory is even more striking. 30.000 barriers interrupt Austrian streams. This is more than one each river kilometer. In the past 15 years special attention was paid to river connectivity in the Austria river management agenda. About 1.500 barriers have been equipped with fish-passages. A small share of barriers could even be removed entirely. A recently study identified about 260 removal projects in Austria so far. Even huge sediment check-dams and small hydropower plants could be removed. A comparative analysis of measures clearly showed that removal of barriers is more effective and cheaper than the construction of technical fishways. Still dam removal is considered and implemented only in exceptional circumstances. To restore free-flowing rivers and reach the goal of the biodiversity strategy the level of ambition must be raised and administrative obstacles have to be cleared.

Best match on Reka catchment: River barrier inventory with awareness raising activities

Eva Horvat, Ana Kričej, Damjan Habe, Polona Pengal

REVIVO, Dob, Slovenia

In 2023, as part of the Open Rivers Programme project, our goal was to prepare the first detailed database of river barriers in the Reka catchment using citizen science activities. We achieved this with the help of XX volunteers, who tracked YY river barriers and walked ZZ kilometers. We also received unexpected SS letters of concern. The most numerous barriers tracked in the Reka catchment were weirs (RR) and culverts (PP), but there were also fords, sluices and ramps. After completing the inventory, we were able to compare the official data where, after conducting a desktop survey, 1.145 barriers were identified. Comparing both will aid us in planning future feasibility studies and dam removals. For many years in Slovenia the public discourse on rivers has resolved around flood protection, efficient water drainage and use of water for powering mills, typical in the past in Reka catchment. The plastic boom period highlighted the pollution of rivers as a significant environmental issue. The “new” environmental issue of river barriers and their negative effects on river ecosystem raised concerns among general public. Individuals with a biological background and nature enthusiasts supported the cause. However, some older people expressed concerns about the potential impact of barrier removal on flood protection, since public discourse around river management in Slovenia is still promoting barriers as flood protection structures. Another concern raised was the cultural heritage-value of barriers and the mills installed on them. We have addressed these concerns through open dialogue and stakeholder engagement.

Can people's engagement facilitate dam removal processes? Lessons learned from a case study in Portugal

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1 - GEOTA, Lisbon, Portugal. 2 - Santarém Municipality, Santarém, Portugal. 3 - Erio, Porto, Portugal

The importance of free-flowing rivers is increasingly recognised by EU environmental policy, in particular the Water Framework Directive and the Biodiversity strategy for 2030. In fact, much of the anthropogenic pressures on river ecosystems are originated by barriers to river connectivity that cause longitudinal, vertical or lateral discontinuity. Recent studies confirm that there are more than a million barriers to river connectivity in Europe and, according to the Portuguese Environment Agency, around 13.000 in Portugal. In April 2023, GEOTA (a Portuguese Environmental Non-Governmental Organisation) together with several stakeholders (Portuguese Environment Agency, municipalities, experts, and riverine population) have removed an obsolete dam on Alviela River. The process included preparatory meetings with specialists and the municipalities involved, the development of a river restoration project, and public sessions to inform and engage local population in the project. The aim of this article is to discuss problems and opportunities identified to contribute to restore the connectivity of river ecosystems in Portugal and how can the participation process can be improved, considering the gaps identified in Alviela dam removal. We suggest that the development of local initiatives, with the integration of participatory processes, is an important step towards a national strategy for the removal of obsolete dams in Portugal. In fact, actors' engagement will contribute to a better understanding of the relation between river rehabilitation and climate action.

B2 Dam Removal – Small barriers (sponsored by Princeton Hydro)

Dam removal is not just about dam removal

Geoffrey Goll

Princeton Hydro, LLC, Trenton, USA

Dam Removal has become synonymous fish passage restoration. But it is much more than simply the reconnecting the upstream and downstream segments of rivers. As practitioners and advocates, how well versed you are in all the benefits will determine success or failure of a dam removal project before it ever gets started, including how it will help people. It is about balancing the values of stakeholders with sometimes conflicting objectives and overcoming the challenges of sediment management and protection of infrastructure; and additional opportunities for restoring the natural capital that rivers provide. Most dams around the world developed around historic mill dam operations. While no longer serving their original function, they remain a central element of communities, with deep emotional connection. It is important that concerned stakeholders understand all of the benefits of dam removal, and not just the restoration of aquatic organism passage. This presentation will illustrate the multi-dimensional restoration possibilities and community benefits that can be achieved when dam removal is viewed from perspectives such as water quality improvement, flood risk reduction and health and safety improvements, greenway connection, recreation and ecotourism, education, sustainable and resilient communities, and increased biodiversity. The presentation will also provide a broad review of the values of existing dams and their impoundments, the institutional and physical challenges of removal, and examples of successes of removed dams within communities, focused on the east coast of the U.S., and those lessons learned that could be brought to the European landscape of ecosystem restoration.

How dam removal has opened up >1817 km of river in Europe

Kerry Brink

WWF Netherlands, Netherlands

In Europe, the dam removal movement is growing momentum thanks to a number of promising developments, including Dam Removal Europe initiative, €42.5 million available through the Open Rivers Programme and of course the EU's ambition to open 25.000 km of rivers. World Wide Fund for Nature (WWF), through the Living European Rivers initiative, continue to contribute to scaling up these activities and multiplying EU targets with the ultimate goal of barrier removal being a widely accepted measure for river restoration by 2030. Currently 20 European WWF offices are working on this common goal by facilitating implementation of removals, communicating about the benefits and continued lobbying at national and EU level. This has results in opening up >1817km of river and >27 dam removals from Finland, Slovakia, Montenegro, Ukraine, Germany, UK, Portugal, Spain and Latvia. The removals in Montenegro, Slovakia, Portugal and Latvia were among the first ever documented in the respective countries, while barrier removals in Ukraine opened >500km of river in Carpathians. In this presentation, the successes and lessons learnt will be discussed with various case studies. We will also explore the scaling up of dam removal in Central and Eastern Europe and the Balkans and the project funded by European Open Rivers Programme to build a movement in the region and a pipeline of 100 dams to be removed in the next 3 years.

The sustainable 'nature-based' management of dam and weir structures: Design and implementation – Case studies from Scotland, England and Iceland

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The management (up to full removal) of dams, weirs etc. aims to improve geomorphic and ecological river continuity. Such actions have significant potential to protect fisheries from current and future impacts from, for example, engineering/ land use pressures and climate change. While such structures are known to impact the passage of fish and habitats in the impounded reach, there are also significant biophysical benefits from reinstating natural sediment transport processes. However, in order that such work can be sustainably undertaken, it must consider, (1) the likelihood of upstream/ downstream channel adjustment and, associated with this, (2) the potential risk to local infrastructure. We present case studies that represent a spectrum of approaches to the 'nature-based' design and implementation of dam/weir management across diverse environments, ranging from full removal (Bronie Burn, River Ythan, Aberdeenshire, Scotland) to replacement with a more sustainable structure (Bowston Weir, River Kent, Cumbria, England) to structure retrofitting (Andakilsa River, West Iceland) to downstream habitat mitigation (River Shin, Sutherland, Scotland). These projects all had to consider the sustainable management of sediments, including such issues as the benefit to biodiversity, implications of risk to local infrastructure, landowner 'buy-in', longer-term physical channel evolution and wider ecological improvements.

Improving river governance: Removal of dams on the Ega River

Josu Elso Huarte (1), Camila Kuncar (1), María Eugenia Hernando Pascual (2), Miriam Pardos Duque (3)

1 - Iberian Centre for River Restoration CIREF, Spain. 2 - Department of Environment, Government of Navarre, Spain. 3 - Ebro River Basin Authority, Spain

The Open Rivers program funds projects that lead to the removal of small dams and the restoration of rivers across Europe, offering a great opportunity to promote river governance by involving NGOs in such restoration. CIREF submitted a proposal to the call that has been selected by the program for funding to develop two projects in the Ega River basin, a tributary of the Ebro in its left side, in the Foral Community of Navarra. The projects foresee the removal of two dams (Arquijas and Gastiáin Mills) included in a Natura 2000 site. Collaboration with the Government of Navarra and the Ebro Hydrographic Confederation (CHE), competent authorities, has been fundamental. Throughout 2023, CIREF has been working on the execution of the projects. In the case of the Arquijas dam, which is about the drafting of the demolition project, it is now in its final phase, while the Gastiáin dam, which corresponded to the demolition of the dam, we have encountered great opposition from the town councils and neighbours in the area, so it has not been possible to carry out the demolition this year and an extension of one more year has been requested to try to resolve this opposition. It is therefore necessary to disseminate the details of the project so that other entities decide to get involved by establishing alliances with the water authorities and, on the other hand, to discuss best practices and recommendations for working with the local opposition that has arisen around dam removal.

Giov & Go: Free-flowing Giovenco. Defragmentation interventions on the Giovenco River: Connecting stakeholders to reconnect the river

Giandomenico Mercuri (1), Mario Cipollone (1), Ileana Schipani (1), Nino Minicucci (1), Amilcare D'Orsi (1), Angela Tavone (1), Enrica Calò (1), Francesco Verrocchio (1), Marco Seminara (1,2)

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The Giovenco is a small river in the Italian Apennines which crosses an area rich in biodiversity within the Abruzzo, Lazio and Molise National Park. Along its short mountain course there are 15 dams meant for different uses, such as hydroelectric, hydraulic defense and irrigation, which have altered the river ecosystem. The project, financed in 2022 by the Open Rivers Programme and conducted by Rewilding Apennines, proposes the removal of 5 weirs which were built in the 1980s to stabilize the riverbed. A team of professionals carried out the technical studies and animation initiatives with the aim to remove the weirs and return 15 km of watercourse to flow free, restoring its longitudinal continuity as an element of ecological connection. Rewilding Apennines involved the National Park, the municipalities of the valley and various stakeholders (associations, entrepreneurs, schools and citizens) to illustrate the reasons for the project. What emerged was a lack of knowledge about the importance of river continuity and a generalized fear of flood risk. During the research it was therefore important to create a hydrodynamic model to simulate flood events either in the presence or absence of dams. This study, submitted to the regional Civil Engineers (Authority for the verification of hydraulic risk), obtained a permit to proceed with an executive project. Environmental investigations and initiatives to disseminate the results are being completed, as we are confident that we have taken the right way to receive funds and permits for rewilding the Giovenco River.

C2 River restoration for LIFE (EU LIFE projects)

LIFE Living rivers: Restoring rivers in Slovakia

Katarina Mravcova

Water Research Institute, Bratislava, Slovakia. Slovak Technical University, Bratislava, Slovakia

Strategic LIFE IP "Living rivers: Implementation of river basin management plan in selected sub-basins in Slovakia" (2023-2032) addresses mainly hydromorphological measures in synergy with sustainable forest and land management in riverine areas and strengthening population of original fish species. In Slovakia, almost 60% of surface water bodies fail to reach good ecological status as required by the WFD while the implementation of RBMP is rather slow. Almost 350 km of rivers will be targeted by the project, covering various types of rivers: mountainous Bela River in the Tatry National Park, main Danube tributaries Hron and Ipel and the Danube itself. Reconnection of 14 km of sidearms, 3000 ha of floodplains, removal of 15 barriers and restoring at least 70 km of free-flowing reaches will be implemented. The Danube River and its floodplains (former inland delta) on the Slovak-Hungarian border have been affected by the construction of Gabcikovo HPP and its by-pass canal. The structures of the HPP are not passable for fish nor sediments. The project team of engineers and biologists work on the fish pass design for sturgeon species and restoration of migration corridors and habitats. Active measures (in-situ breeding, juvenile re-stocking) will strengthen sterlet population. Detailed monitoring, stakeholder cooperation, bilateral and international cooperation, capacity building, complementary actions and mobilisation of funds are important parts of the project. Project partners as key stakeholders in river management, applied research and nature protection will cooperate in full to improve the ecological status of rivers in Slovakia.

LIFE CONNECTS creates free flowing rivers in Southern Sweden

Karin Olsson, Vibeke Lirås

County Administrative Board of Scania, Malmö, Sweden

Dam removals are widely considered one of the most significant measures in river restoration conveying positive benefits for aquatic and terrestrial biodiversity. The transformation of currently impounded areas upstream dams to lotic habitats will affect the rivers hydrology, water quality and biodiversity substantially at the same time as it improves the rivers resilience to climate change. Most rivers in Sweden are negatively affected by barriers and alterations of the rivers hydromorphology. The lack of river connectivity is particularly critical for sea migratory fish such as Atlantic salmon (Salmo salar), European eel (Anguilla anguilla) and brown trout (Salmo trutta). By taking a catchment approach for river restorations, cost-effective solutions can be used at a larger scale and several stakeholders can work together to restore our rivers creating free flowing rivers that improves the status of migratory fish populations as well as the overall biodiversity in and around rivers. In Southern Sweden the LIFE CONNECTS project which started 2019 have removed both smaller and larger barriers and restored over 50 hectares of river habitat and more will be done the following years.

LIFE Agueda – Restoring river connectivity for migratory fish in the Vouga River basin

Sílvia Pedro (1), Carlos M. Alexandre (1), Catarina S. Mateus (1), Bernardo R. Quintella (2,3), Joana Boavida-Portugal (1), Maria João Lança (4,5), Ana F. Belo (1), Esmeralda Pereira (1), Ana S. Rato (1), Inês C. Oliveira (1), Sara Silva (1), Pedro Almeida (1,6)

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The LIFE Águeda project (LIFE16 ENV/PT/000411), ongoing since 2017, aims at restoring river connectivity in the Vouga River basin, central Portugal. The Vouga River basin is important for several migratory fish species, some of which are of high socio-economic and conservation importance, such as the allis shad, the sea lamprey and the European eel. It is also home to sea trout, twaite shad and thin-lip grey mullet, as well as Iberian barbel, Iberian nase, Douro nase and brown trout. For all these species, habitat loss and degradation are probably the main threats, followed by overfishing and poaching of the most valuable species. The main objective of LIFE Águeda was to remove the hydro-morphological pressures in the Vouga basin to achieve good ecological status, as required by the WFD and associated RBMPs. This involved restoring the river morphology of the Agueda and Alfusqueiro rivers by removing eight river barriers, constructing five fish passes and restoring the riverbed. A monitoring programme using PIT antennas in the most upstream fish passes in each river will evaluate the effectiveness of these measures. These interventions were accompanied by riparian habitat restoration, design and operation of a European eel pilot translocation program, management of recreational and commercial fisheries, and stakeholders' engagement, safeguarding compatibility of ecosystem uses. As the project draws to a close, we assess its achievements and what remains to be done. LIFE Agueda's commitment to returning rivers to migratory species will continue in the LIFE REVIVE project, which is currently being evaluated for funding.

Reviving freshwater pearl mussel populations and their habitats – LIFE REVIVES

Patrik Olofsson

County Administrative Board of Norrbotten, Luleå, Sweden

In September 2021, the EU LIFE Programme admitted a 9,5 M € grant for a six-year LIFE Revives project (total budget 15,9 M €), aiming at conservation of freshwater pearl mussel (FPM, Margaritifera margaritifera) and its habitats and host fishes (Atlantic salmon, Salmo salar, and brown trout, Salmo trutta) in Finland, Sweden and Estonia. The project is led by the University of Jyväskylä (JYU, Finland) and will be carried out by 12 partners in total. The project area covers 69 rivers representing 7% of FPM populations and 17 Natura 2000 areas across the project countries. In addition, FPM juveniles will be produced for reintroduction to rivers at Konnevesi Research Station (JYU) and Põlula Fish Farm (Estonian State Forest Management Centre). The aim of the project is to achieve improved conservation status and/or adequate recruitment of FPM, Atlantic salmon and brown trout. Restore 117 km (80 ha) of FPM river habitats, remediate 50 migration barriers for fish and block 370 ditches in FPM catchment areas. Increased commitment to FPM conservation/management among authorities, stakeholders and policy makers, and more unified FPM and salmonid conservation methods and know-how in Europe. Disclaimer: The project (LIFE20 NAT/FI/000611) has received funding from the LIFE Programme of the European Union. The material reflects the views by the authors, and the European Commission or the CINEA is not responsible for any use that may be made of the information it contains.

LIFEDeeRiver, restoring one of the most regulated rivers in Europe

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LIFEDeeRiver is an ambitious €8m+ project working on the River Dee in north Wales to improve the status of iconic species and habitat within the Special Area of Conservation (SAC), including Atlantic salmon and lamprey. The Dee is one of the most regulated rivers in Europe, providing drinking water to over 3m people across north west England and north Wales. Through the project, we are removing or altering up to 14 structures within the river, including 70 metres wide by 3 metre high weirs; working on a UNESCO world heritage site to improve fish passage and many other small weirs that are being removed. These removals will improve fish passage throughout the river for a wide range of species, and importantly improve the natural fluvial processes. Land management interventions (40km+ of fencing, soft revetment, 15,000+ trees planted), have also been carried out to reduce the input of sediments and nutrients to the watercourse, further improving the habitat. Introduction of 5,500 tonnes of spawning substrate/ gravels back into the river below regulation reservoirs has provided vital spawning habitat, depleted since the reservoirs were constructed, for salmon. We would discuss the approach to the work, lessons learnt and how we are ensuring the future resilience of the river. AECOM have supported the project through designing fish passage means at 5 weirs, each with unique constraints and opportunities. Funding has come through the LIFE programme, as well as Environment Agency, Eryri National Park, Dwr Cymru/Welsh Water, Welsh Government and Natural Resources Wales.

D2 Hydropower development vs free-flowing rivers

Navigating change to mainstream barrier removal: Using a Nature-based Solutions (NbS) approach with the hydropower sector across Europe

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There is a drive to mainstream barrier removal and develop free flowing rivers across Europe, yet tensions between restoration and hydropower objectives remain. Using a Nature-based Solutions (NbS) framing can help change this, where the hydropower sector is a potential partner in barrier removal. Within H2020 MERLIN we are working with the sector to identify strategic actions for navigating this change to NbS thinking. Key strategic actions include: (1) highlighting that the sector has a role, even if hydropower dams are a sub-set of the barriers to remove, (2) disrupt assumptions that frame restoration as a threat – e.g. increasing understanding of what an NbS approach with barrier removal involves and potential social and economic benefits for the sector, (3) build on willingness of the sector to undertake non-hydropower obsolete barrier removal, (4) support the EU obsolete barrier removal programmes that fosters collaboration and engagement, (5) build on existing barrier identification and prioritization tools to develop, with the sector, open-source catchment scale, holistic (multiple issues) decision support tools to achieve greatest impact, (6) adapt hydropower related policies to reduce incoherence with nature policies to align with EU Green deal objectives, (7) adapt national hydropower licences to consider after use and direct resources towards NbS involving barrier removal. This involves working together to change thinking within the sector about barrier removal - highlighting why and how barrier removal could be beneficial. Other institutions involved in hydropower and barrier removal also need to evolve their approaches to facilitate these actions, which may require shifts in organisational culture and capacity.

Stakeholder collaboration as part of the Swedish national plan for Modern Environmental Provisions for Hydropower

Peter Rudberg

GeoViable, Spain

The Swedish National Plan for Modern Environmental Provisions for Hydropower (NAP) aims to ensure that hydropower projects are provided with modern environmental provisions in a way that maximizes benefit to the aquatic environment and an efficient supply of hydropower electricity. Stakeholder collaboration is included as a formal step in the NAP process, which is a novelty in Swedish environmental governance. The stakeholder collaborative process, serves as a preparatory step towards the court proceedings in which the permits for hydropower production are modified according to the existing legal framework. At present more than 30 collaborative processes, involving many more hydropower installations, have been finished and multiple hydropower permits are reviewed in the Swedish Land and Environmental courts, with some installations having had their permits modified or decommissioned to allow for river restoration. The presentation will provide an update of the NAP and discuss the functioning of the collaboration process as part of the hydropower permit review.

Conservation challenges in the Aoos River basin: The threat of small hydropower plants

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The growing demand for energy production from Renewable Energy Sources (RES), driven by the European Green Deal and the REPowerEU plan, is exerting significant pressure to construct new hydroelectric power plants. The 2019 National Energy and Climate Plan (NECP) of Greece outlines a 15% increase in installed capacity for hydroelectric power plants by 2030. One area of interest for new hydropower projects is the Aoos River basin in Epirus, known for its pristine rivers and untouched landscapes. The Aoos River, or Vjosa in Albania, has retained a widely unobstructed fluvial morphology over its entire river corridor. However, it faces a looming threat from the construction of numerous Small Hydropower Plants (SHPs) which could result in river fragmentation and disruption of hydrological continuity. The unchecked expansion of SHPs thus poses threats to vital fauna and especially fish populations including several endemic or vulnerable species, as well as important habitat types of both national and community interest. Despite multiple protective designations, including its overlap with the Northern Pindos National Park and thirteen Natura 2000 sites, the Aoos River basin remains vulnerable to the proliferation of SHPs. In this research, we examine the spatial distribution of existing and 48 planned SHP projects in Aoos' River basin to assess current pressures and threats poised to its conservation status. Our study raises questions about the adequacy of existing and proposed protection measures in the face of SHP development and advocates for robust conservation measures to protect this ecologically valuable corridor and its pristine natural environment.

Strategic restoration and development scenarios to mitigate fish habitat fragmentation for low-impact hydropower in the Mekong

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Dams play a vital role in water security, energy supply, and flood protection, but also fragment freshwater fish habitats. This endangers freshwater biodiversity and the well-being of communities reliant on freshwater fish. While only 37% of rivers longer than 1,000 km remain free-flowing, plans for expanding hydropower capacity may exacerbate fragmentation in fish diversity hotspots like the Amazon, Congo, and Mekong basins. Addressing these challenges requires strategic planning combined with restoration strategies to minimize cumulative environmental impacts. Our innovative approach combines strategic restoration and development to identify opportunities for low-impact hydropower in the Lower Mekong Basin (LMB). Using a genetic algorithm and species-level habitat connectivity model, we explore policy scenarios to strike better trade-offs between hydropower supply and fish habitat connectivity for 751 fish species. Our scenarios range from low ambition (strategic planning only) to medium ambition (strategic planning and fishways installation), to high ambition (strategic planning, fishways, and removal of most impactful dams). Results reveal modest gains in low and medium-ambition scenarios, with connectivity improvements of up to 5%. However, the removal of the 12 most impactful dams in the high-ambition scenario increases connectivity by 30%. Policy interventions' effectiveness varies by fish species group but remains consistent across ambition levels. Our restoration-development scenarios offer insights to mitigate the adverse effects of past ad-hoc dam development and foster ecologically and economically favorable hydropower pathways in the LMB. Implementing such strategies can help preserve freshwater biodiversity and promote sustainable hydropower development in the region.

Conservation requirements of European eel (Anquilla anquilla) in a Balkan catchment

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The European eel has been declining throughout its area of distribution, is addressed in several pieces of legislation, and is the target of extensive restoration efforts. Therefore, investigating and conserving natural eel habitats is urgently needed. Large, near-natural rivers have become rare in Europe but the Balkans host some of the extant examples. The data that is currently available detailing the river habitats of the European eel in the whole Mediterranean region is scarce, rough, and unreliable, and further research is therefore urgently needed. Exemplary, in this talk we synthesize European eel catch data from four institutions and the results of an electrofishing and eDNA survey in the Vjosa River, Albania. Population density and structure as well as habitat choice were studied at different spatial scales. We calculated densities for different meso-habitats and three different hydromorphological channel sections. However, several Balkan rivers are under threat from planned hydropower (HPP) constructions. Here, three main arguments are raised against the proposed development of HPPs with a focus on European eel: (1) ecological degradation of large, unique river systems and consequent habitat and connectivity losses, (2) violation of signed laws and conventions (national and international), and (3) insufficient mitigation measures (e.g. bypasses). By linking study results to relevant legislation and literature we provide evidence-based data for water management decisions. Considering the current dramatic situation regarding stocks and the extensive restoration efforts being made, it is apparent that the conservation of suitable freshwater habitats is one of the most significant issues in eel conservation.

E2 Small scale fish passage solutions

Resolving recruitment bottlenecks for the critically endangered European eel

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Conservation of the European eel has focused on reducing adult mortality, whereas the juvenile life-stages have received less attention. In this project we focused on juvenile eel recruitment to fragmented rivers, specifically during the phase when eels enter freshwater and migrate towards their rearing grounds. Eel occurrence data were spatially and temporally integrated with the national databases of dams and FPSs in a GIS environment to evaluate their effect on ascending eel distribution. Dams fitted with eel ramps or technical fishways, as well as dams without any measures, reduced eel occurrence upstream. This negative effect was not found for dams fitted with nature-like fishways. To further explore the observed poor performance of eel ramps, three commonly used eel climbing substrata were evaluated in a controlled experiment. We found that studded substratum outcompeted open weave and bristle substrata. The studded substratum attracted more approaches and initiated climbs than the other substrata, but passage success rates did not differ between substrata. The results were supported by data from a field validation. The new knowledge provided by the project are of paramount importance for the next steps of management strategies with the ultimate goal of preserving the European eel population.

Analysing the behaviour of migrating fish to predict movement near barriers

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Freshwater fish migration is increasingly impacted by riverine barriers. To mitigate barriers, understanding of fish behaviour is necessary – how do fish move in the altered environment near a barrier? Which environmental parameters are important? How does behaviour vary between individual fish? And how may movement change under different flow regimes? By analysing real fish movement and forming predictive models, these questions can be addressed and inform barrier management to improve fish passage. Here, hidden Markov models and step selection functions were combined to analyse fish behaviour and movement with the ultimate goal of prediction. Barbel (Barbus barbus) and grayling (Thymallus thymallus) were tracked during their spawning migration via 2D acoustic telemetry. Hour-long tracks where the fish approached the fish pass were identified, to analyse behaviour when fish may be attempting to pass. Hidden Markov models were used to differentiate behavioural states and split the data into each state – specifically resting/searching behaviours and transit behaviour. Habitat selection analysis was conducted for each behavioural state on the individual level, comparing movement to a range of habitat parameters. Model selection was performed to determine the optimal model per individual and resulting models pooled to describe general trends and individual variation. Models were assessed via cross-validation using simulated tracks, to evaluate model predictability. An individual based model was then developed, to simulate the movement of barbel and grayling and predict spatial usage across eight riverine discharges, demonstrating patterns of usage under different conditions.

Can’t pass or won’t pass: Quantifying improved connectivity for riverine brown trout at a low-head gauging weir

Jamie Dodd, Ian Cowx, Domino Joyce, Jon Bolland

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Anthropogenic fragmentation of longitudinal connectivity in rivers has had negative impacts on riverine fish species globally. Vast numbers of fish passes have been constructed to reverse these impacts, often at considerable expense, but their efficiency is rarely quantified. Further, it is hence inherently difficult to perform pass assessments for riverine fish that are not obligated to perform an upstream migration; it is not known if fish cannot pass due to behavioural or physiological reasons or do not pass due to a lack of motivation. During this study, Passive Integrated Transponder (PIT) telemetry was used to compare movements of displaced and non-displaced riverine brown trout (Salmo trutta L.) through a low-cost baffle (LCB) fish pass on a low head gauging weir in England. Brown trout are known to perform a homing movement when displaced, and thus displaced fish were assumed motivated to move while non-displaced fish were not. A significantly higher proportion of displaced fish approached and entered the fish pass in comparison to non-displaced fish, and thus overall passage efficiency was also significantly higher. The size of non-displaced and displaced fish that approached the weir did not differ but the size of displaced fish that entered the fish pass were significantly larger than displaced fish that approached but did not enter. It was hence concluded that majority of non-displaced fish did not pass due to lack of motivation whereas smaller displaced fish did not pass due to physiological capability.

Monitoring results show slow recovery of lamprey reproduction after construction of a country wise first natural fish passage

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BIOR, Riga, Latvia

Fish passages, when properly installed, have proven to be one of the solutions for migratory fish species to reach their spawning grounds when complete removal of a particular barrier is not possible. The River Rīva is a 60 km long river that flows into the main Baltic Sea. The barrier (remains of a paper mill dam) in the River Rīva is located 1.2 km from the river mouth. The remains are incorporated into the replica of a historic bridge and therefore cannot be removed. Construction and improvement of the first natural fish passage in the River Rīva was carried out in the summer and autumn of 2021. The success of lamprey reproduction was estimated by bottom sampling, which consisted of 18 sampling points upstream of the barrier. Lamprey larvae were divided into three age groups (0+, 1+ and >1+) depending on the total length of a specimen. The results show a slight increase in the mean density of 0+ lamprey larvae (IRR2020vs.2022=1.85 (95%CI 0.60-5.73), IRR2020vs.2023=2.44 (95%CI 0.79 - 7.50)), but the increase is not statistically significant (p2020vs.2022=0.288, p2020vs.2023=0.120). Thus, it can be concluded that the construction of a natural fish passage can be a convenient way to overcome the negative effects of a migration barrier. However, complete elimination of the negative effects on migratory fish can only be achieved by complete removal of the barrier.

Ten years of adjusted tidal barrier management to enhance glass eel migration at the Belgian coast: what have we learned?

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An unobstructed migration route between the spawning area in the Sargasso Sea and the freshwater growth habitats in Europe is crucial for the European eels' long-term survival. Every spring however, millions of glass eels arrive at the European coast to find their inland migration routes blocked by tidal barriers like weirs and sluices. Therefore, adjusted tidal barrier management (ATBM), i.e. setting the tidal sluice doors ajar during tidal rise, was adopted at multiple tidal barriers near the Belgian coast over the past ten years. The influence of ATBM on eel density in inland waterways has been evaluated ever since, with glass eel gutters at several sites spread over the coastal area, and with a mark-recapture study of eels in a canal. Results from the eel gutters have proven that ATBM supports the eel populations with new recruits, and the mark-recapture study shows an increase in eel density in the Leopold canal over the past eight years. Hence, the results support the success of ATBM as a mitigation measure for migration obstruction of glass eels after arrival at tidal barriers. However, this effective management measure may come under pressure due to climate change, resulting in drier springs leading to a rise in salinity in inland waters, which is unfavourable for agriculture. So, challenges still remain, specifically in quantitatively monitoring the impact of ATBM in terms of eel density, as well as in implementing ATBM due to conflicts with agriculture.

A3 Freshwater fish & fisheries: Restoration of migratory fish populations

What do fish do during and after the opening of a migration axis? An analysis of their colonization dynamic

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The monitoring of fishways is rarely carried out during several consecutive years after their opening and the behavior of fish released upstream is never studied. This study carried out over several years highlights the colonization dynamics of fish populations. We carried out monitoring of three fishways on three rivers in Belgium from their opening up to 3 to 8 years. We analysed temporal patterns in specific diversity, abundance, biomass, and associated environmental conditions. We captured from 13 to 23 species and we detected different capture peaks and the arrival of new species sometimes several years after opening the migratory axis. The analysis of the periodicity of capture indicated that some species made movements throughout the year while others at more precise periods. We used manual radiotelemetry to tracked individuals belonging to four species (trout, nase, grayling and barbel) after their release upstream of two obstacles in the Ambleve River. We observed a diversity of movement behaviours and habitats used among the studied species. All the species used potential spawning habitats in the new occupied river stretches with distances travelled from 13.7 km to 77.8 km, trout also used tributaries and sub-tributaries. This study highlights the benefits of opening a migratory axis at time T0 when individuals use the fishway and at time T+1 by studying the post-crossing behaviours of individuals. It highlights the benefit to realize long-term and transversal research.

A toolbox to assess the spatio-temporal dynamics of Atlantic salmon recolonisation after dam removal on the Sélune River (Normandy, France)

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The recolonization of the upstream part of the Sélune River catchment (Normandy, France) by diadromous fish species began in July 2022 when the second large dam was removed. A third of the watershed, which represents around 1000 km of flowing habitats, is now accessible to these species, including the iconic Atlantic salmon, after a century's absence. Historical documents and the presence of ruins of former fisheries upstream attest of its wide distribution and abundance from the Middle Age to the 20th century. Here, we present the toolbox that has been designed as part of the Selune scientific program to track the dynamics of Atlantic salmon recolonisation. To do that, we combine traditional and modern approaches such as telemetric tracking of spawners, counts of redds, electrofishing of juveniles' habitats, eDNA and acoustic camera monitoring. Fish tissues are also collected to further study the demography and population genetics of salmons in this area. In our presentation, we will focus on the first evidence of upstream colonisation by salmon individuals few weeks after dam removal, and proof of reproduction in the following winter 2022-2023. We will also discuss other benefits of dam removal, including thermal regime and habitat quality in the river, to show how connectivity improvement may contribute to mitigate adverse effects of climate change on Atlantic salmon populations.

Removal of lake outlet dams in Sweden and its effects on fish communities

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Dams in inland freshwaters have large effects on ecosystem processes and function. Within the near future, more than 50 lake outlet dams will be removed in central Sweden, which provides a unique opportunity to quantify the effects of inland dam removals, including a possibility to achieve results with good generalizability. We took advantage of these planned dam removals, and we are carrying out a large-scale replicated semi-natural field experiment, in which we sample and measure nutrient status, biomass of phyto- and zooplankton, aquatic plants and fish. We are currently analyzing data from two years of gill net fishing collected within the project, combined with ample existing historical data, to provide insight into how fish communities respond to lake outlet dam removals. We are using both a before-after-control-impact design and a time series analysis of older removals, and we will present potential changes in fish biodiversity, in predatory fish abundance as well as in the demography of European perch, caused by the dam removals. In addition, we will show how these changes relate to other factors such as nutrient status, water chemistry and plankton density.

The establishment of the Trans-European Swimways Network and Swimways of European Importance

Emma Cordier

Wetlands International Europe, Netherlands

To address the myriad threats facing migratory freshwater fish species in Europe, Wetlands International Europe, along with partners from the World Fish Migration Foundation, IUCN, and UNEP-WCMC, established the Trans-European Swimways Network (TEN-S). This Network brings together stakeholders to foster international cooperation in improving knowledge and guidance, as well as raising the profile of fish migration and strengthening policies for their protection. TEN-S has collaboratively produced a Trans-European Swimways Programme which outlines the key threats and opportunities for migratory freshwater fishes, and provides a framework for action over the coming years. One of the first major actions has been the development of criteria and its application for the identification of the Swimways of European Importance (SEIs). We acknowledge that not all corridors for migratory fishes can be protected, and so there is a need for a prioritisation of habitats. The goal of SEIs is to create an inventory of key river stretches as “hotspots” for barrier removal and other conservation measures to protect migratory freshwater fish species. Drawing on the Global Swimways approach, SEIs will be based on biological, economic, and cultural criteria. As a starting point in 2023, SEIs were identified according to preliminary biological criteria based on IUCN Red List data at different geographic scales, combined with data from key European and EU legislation. Classifying the data according to species richness of migratory fish resulted in over 400 SEIs, which are currently being further refined and analysed. This presentation will showcase TEN-S and its work on identifying SEIs.

Parasitic freshwater pearl mussels induce upstream movement in their brown trout hosts: Early evidence of an extended phenotype

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Unionid mussels are adapted to parasitize fish and can affect host behavior, habitat use, and growth rates, raising the question if parasitic freshwater mussels can also manipulate their host fish to reach habitats favorable for newly excysted juvenile mussels. Wild-caught juvenile brown trout (Salmo trutta) with no history of infestation were PIT-tagged, half of them infested with parasitic larvae from the endangered freshwater pearl mussel (Margaritifera margaritifera), and then returned to their home stream stretch. The trout were tracked for one year to investigate movement and habitat use, and occasionally recaptured to monitor health status. Infested trout showed significantly higher upstream movement at 60, 90, and 270 days post-infestation (dpi) compared to non-infested individuals. As glochidia of this mussel species begin to excyst after approximately 270 dpi, these data suggest that the juvenile mussels were successfully transported an average of 170 m upstream from the host fish release point. Infested trout showed a significantly lower specific growth rate at all stages of the study when compared to non-infested trout, an effect that we propose acts as the mechanism to induce host movement. Infested individuals were recaptured more often in sections with slower moving water and smaller substrate sizes; and in shallower wide stream sections only during the excystment period. These results indicate a first example of extended phenotype in unionid mussels and highlight the importance of understanding glochidia-induced changes to host fish behavioral ecology for future mussel conservation and the importance of free-flowing, unfragmented rivers.

B3 Nature-based Solutions

Building blocks for upscaling freshwater Nature-based Solutions in Europe

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Environmental degradation and climate change are increasingly posing significant challenges to society, demanding a departure from the business-as-usual approach in favour of comprehensive solutions. These challenges are so profound that they necessitate nothing less than a societal transformation. Key to this transformation are nature-based solutions (NBS), which hold great potential in mitigating environmental issues. Among these solutions, freshwater restoration and dam removal have emerged as impactful examples. While NBS are gaining recognition worldwide, they are still far from becoming mainstream. Mainstreaming entails making these solutions common sense, aligning them with community practices, institutional settings, economic rationale, and political consensus. To bridge this gap, effective upscaling of NBS is imperative. The EU innovation project MERLIN has been actively engaged in upscaling NBS, focusing on five essential building blocks: a holistic review of the state, crafting a narrative of the future, reliance on evidence-based approaches, fostering participation and inclusion, and securing necessary resources. This presentation introduces these five building blocks within the context of upscaling freshwater restoration, including dam removal, and aims to provide a practical guidebook for mainstreaming NBS. By addressing the key elements necessary for successful upscaling, we seek to facilitate the integration of NBS into common practices, thereby driving the much-needed societal transformation to combat environmental degradation and climate change.

Natural sponges: Wetland solutions to protect against floods and droughts

Paul Brotherton

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The case for rapidly restoring "natural sponges" has never been more urgent. Europe is experiencing the ecological, economic and human health impacts of the climate crisis through an ongoing cycle of extreme weather, droughts, fires and floods. Despite the recognition in the EU Strategy on Adaptation to Climate Change that Nature-based Solutions (NBS) such as restoration of the sponge-like function of soils are essential, there is still a lack of awareness of the effectiveness of natural sponges among decision makers. For more than a decade Wetlands International Europe has researched areas with high sponge potential, including in the upstream valleys of the German Middle Mountains of the Rhine and Meuse River basins which were the epicentre of the floods in 2021. Our modelling results are promising: natural sponges can provide a disproportionately large regulatory effect on reducing flood and drought risk and achieving multiple EU policy objectives, making them true multi-benefit NBS. The presentation will connect to our latest pilots and research in northern and southern Europe demonstrating the effectiveness of sponges as NBS: (1) restoration pilot sites in Belgium under Horizon Rewet and in the German Eifel under Horizon SpongeBoost, (2) analysis of the 2021 floods in Germany on the land-use contribution to peak flood discharge and potential sponge solutions, (3) analysis in the Tajo Basin in Spain after the 2023 floods of land-use related causes and NBS solutions. We aim to secure the support of funders, investors and decision makers to deploy natural sponges at the landscape level.

Involving local stakeholders into lateral connectivity restoration along the River Tisza, Hungary

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The lowland areas of the Tisza catchment in Hungary - the Great Plain - suffer from increasing drought, decreasing river levels, reduced water quantities transported by rivers and the lowering of groundwater levels. These trends are intensified by climate change. Water scarcity is causing a decline in biodiversity, damages to agriculture and is a limiting factor for society and the economy. Solutions could include reconnecting former floodplains to the river and extensive water retention - the use of floodwaters and inland excess waters instead of draining them. But this requires space: the keys to landscape rehabilitation are Nature Based Water Retention Measures in land use. For these reasons, the involvement of local farmers and other stakeholders in river restoration is inevitable. WWF Hungary initiated a large-scale river restoration programme with the long-term goal that water retention based, nature friendly floodplain management system is introduced in the Hungarian part of the Tisza River basin, wherever possible, in order to reduce water shortages, to improve biodiversity and provide benefits for local communities. The EU innovation project MERLIN promotes local implementation and demonstration activities in the Bereg landscape and near Nagykörű village along the Tisza, in Hungary. The presentation introduces the results of social and economic research among local stakeholders, the steps taken so far to involve them and the proposed restoration activities. Particular attention will be paid to how the surveys show that economic instruments can be used to motivate land users to apply Nature Based Solutions in agricultural areas.

Nature-based solutions for the Elbe estuary?

Mario Brillinger, Johanna Knüppel, Elisabeth Klocke

Stiftung Lebensraum Elbe, Hamburg, Germany

The Elbe estuary faces significant challenges, including the ecological impacts of increased tidal dynamics in the inner estuary, the need for ecological upgrading of the federal waterway and the Port of Hamburg, and the expected sea level rise of around 80 cm by the end of the century, with all its unforeseeable consequences. While various solutions are being discussed, including the construction of a storm surge barrier, nature-based solutions are largely unrecognised. Nature-based solutions, as defined by Albert et al. (2021), employ and promote ecosystem structures and processes to address societal challenges, underpinned by a clear implementation approach. They often focus on the protection and restoration of natural wetlands, as well as the creation of artificial habitats such as floating islands. The Lebensraum Elbe Foundation actively pursues the development of nature-based solutions, including the ecological improvement of the Hamburg harbour basins through the implementation of floating islands and habitable structures in sheet pile walls, as well as the promotion of mudflat growth in the Elbe estuary as an adaptation strategy. This presentation aims to reflect on the Foundation's ongoing projects in the context of the discourse on nature-based solutions. Although some projects are still in the planning stage, initial conceptual considerations and interim results will be presented to stimulate discussion on how far these approaches can be considered nature-based solutions for challenges in the Elbe estuary. The presentation invites a critical examination of whether the projects meet the criteria for nature-based solutions as outlined by Albert et al. (2021).

Living Danube Partnership for restoration: 1+1+1=5? Innovative partnership between corporate, governmental platform and NGO

Laurice Ereifej

WWF Central and Eastern Europe, Budapest, Hungary

8 years, 9 restoration projects, 13,45 million m3 water replenished, 5300 hectares impacted, 70 million people reached, 20 million EUR indirectly leveraged. The power of partnership is 1 + 1 + 1 = 5. A cross sectoral partnership like this one brings together the very different and complementary expertise, experience, tools and opportunities of each of the partners: the political and institutional framework of the International Commission for the Protection of the Danube River (ICPDR) for the Danube basin; the resources and capabilities of the Coca Cola Foundation and system; the capacity, know how and facilitation of WWF CEE. Conserving and restoring rivers and wetlands is at the core of the activities of those three regional partners. We have certainly achieve(d) more by working together than alone. In the next phase of the partnership, we're raising the bar higher. While the main focus will be still river, floodplain and wetland restoration, NBS pilots with the agriculture sector will also be targeted in order to showcase potential win-win solutions. Opening the partnership toward other corporates, raising their awareness on their water related risks and the necessity to take collective action for better and sustainable river basin management and stewardship is also part of the plans from next year onwards. The presentation will highlight the key interest of the players, the way the partnership was set up and operating, its leverage effect and the future work in the perspective of a changing climate and water-related risks.

C3 Road dams / Culverts retrofitting

A Nature Based Solution at road-stream crossings: Free flowing and flood resilient

Erica Borum

USDA Forest Service, Glenwood Springs, USA

Roads and water interact at each road-stream crossing, dissecting aquatic ecosystems and providing the most common failure location for transportation systems. With climate change, extreme weather events will continue to adversely affect transportation infrastructure and aquatic systems around the world. A solution for infrastructure resilience and unimpeded passage for fish and aquatic organisms is provided by the United States Forest Service's Stream Simulation methodology. Stream Simulation focuses on reconstructing a stable stream channel through the crossing to maintain hydraulic and geomorphic continuity. This ensures passage of flood waters, sediment, and debris, along with fish and other aquatic organisms. Only then is a channel-spanning structure considered. The process begins by making observations of the upstream and downstream channel to determine and measure reference parameters to guide the design. These parameters include slope, width, cross-sectional dimensions, sediment sizes, and bedform types. This approach significantly departs from traditional hydraulic design methods, which typically ignore stream channel dimensions and focus primarily on conveyance of estimated flood discharges. While Stream Simulation still incorporates a hydraulic assessment, it no longer serves as the primary sizing criterion. Rather, it is a check to ensure that a minimum of 20% clearance (freeboard) is maintained during the 1 percent annual exceedance flood. Recent flood events on Forest System Lands have shown that Stream Simulation designs are resilient and capable of surviving 500- to 1,000-year storm events. This ecologically meaningful, flood-worthy methodology is a nature-based solution applicable in any stable stream system.

River obstacles: A new type-attributed road-river crossing dataset for England, United Kingdom

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Culverts, bridges, and fords exist where roads intersect rivers and streams. Given the high density of roads in the United Kingdom, we should expect high abundances of these structures intersecting waterways. Culverts, particularly those that are in poor condition or undersized to the stream and river channels that they encapsulate, can impede movements of species, water, sediments, and materials, and pose risks to human well-being and safety. England's Environment Agency and partners hold a River Obstacles dataset for the country, which contains ~49,000 records of human-constructed infrastructure from dams to culverts. Until 2023, there were a limited number of culverts documented in the River Obstacles dataset, primarily because the structures were not easily identified in the initial desk-based mapping exercises led by the Environment Agency. To address the data-gap, our team first intersected Ordnance Survey's Open Rivers and Open Roads (2019) datasets to determine where road-crossings were likely to occur in England. We then attributed crossing types (culverts, bridges, and fords), using a model-based approach before manual validation using digital mapping tools such as Google Earth and Ordnance Survey's digital maps. In this presentation, we will share the new type-attributed road-river crossings dataset for England and the steps we took to attribute crossing types and to assess accuracy and inter-mapper agreement for the new dataset. We will share an overview of crossing-type distribution and show how potential users can access and use the dataset via the River Obstacles App.

The Swedish transport administrations successful work with removing barriers

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The Swedish Transport Administration is responsible for construction and maintenance of public roads and railways. An important part of the work is to ensure that ecological values are taken into account, i.e. that no barriers are built and also to mitigate already existing barriers. The Swedish Transport Administration works continuously with mitigation of barriers in streams adjacent to public roads and railways in Sweden. The measures are in most cases selected in cooperation with other authorities, for instance The County administrative boards and local fishing conservation associations. When planning measures, it is important to cooperate with other stakeholders to get most ecological benefits in the area/watershed selected. The Swedish Transport Administration is continuously working to improve road/water passages and different kind of solutions are tested, not only for fish and other aquatic animals but also for small and medium sized terrestrial animals such as otter, protected in the Natura 2000 network.

Mapping impassable culverts to be removed in the highly ecologically prioritized Gauja River

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The Gauja river basin is located in the north-eastern part of Latvia, covering almost 20% of the territory of the country and contributes to a large portion of the freshwater biodiversity. The overall ecological water quality ranges from 'moderate' to 'high'. In Latvia, the results of recent modelling have shown that the Gauja River is one of five priority rivers for the protection of fish species nationally, and its tributaries to be important at a regional level. The Gauja RB is relatively open to fish migration since no major dams have been constructed in the lower to mid reaches of the river. An assessment of the ecological impacts showed that hydromorphological changes are a significant factor affecting the ecological status. The assessment didn't take into account the impact of hundreds of unpassable culverts blocking migration routes throughout the catchment. Our project is using GIS mapping techniques to identify all the culverts in the RB (current results show around 10,000 culverts in the basin), and identify which are impassable. Then 100 culverts with the highest ecological impact will be chosen for field visits, to measure the accuracy of the GIS mapping technique. The project aims to develop a methodology which can be replicated over other river basins to quickly and effectively identify impassable culverts. The project will be key to mainstream dam removal as it will help identify a large number of dams which are cheaper and easier to remove than traditional dams.

Connecting water and people by improving road-crossing infrastructure in the Brazilian Amazon

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The Amazon, the world's largest and most biologically diverse river basin, holds 40% of the global reserve of remaining free-flowing waters. Despite such importance, deforestation and infrastructure development have been fueling rapid transformations in freshwater ecosystems caused by disruptions in hydrologic connectivity. Such changes are promoted not only by large infrastructure like hydropower dams, but also by smaller structures like agricultural impoundments and roads. We estimate over 100,000 road crossings at small streams (1st to 3rd order) across the basin, a number expected to grow as both legal and illegal road-networks continue expanding. After examining dozens of road-crossings in situ, we observed numerous cases of inadequate and poorly planned infrastructure, including improvised culverts made from tree trunks and unreliable bank stabilization. These structures modify water and sediment flows and pose risk to people's safety and well-being. In the deforestation frontier, road-crossings are primary predictors of environmental change due to alterations in channel morphology, water temperature regimes and aquatic biodiversity. In this context, our project will deliver a holistic and novel assessment of the biotic and abiotic effects of road-crossings on freshwater ecosystems and lead the first manipulative experiment that attempts to restore hydrologic connectivity in Amazonian streams. The project is now advancing with pre-assessments of stream ecosystems and road-crossing infrastructure in Eastern Amazon, which will be followed by the manipulative interventions in the following years. We recognize the benefits of roads to connect rural communities, and improving road-crossing infrastructure has a high potential of benefiting both Amazonian nature and people.

D3 River protection in the Western Balkans

Achieving durable river protection: The United for Rivers initiative in Southeast Europe

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The United for Rivers initiative, led by The Nature Conservancy, is a regional effort dedicated to preserving the stunning beauty of 13 rivers in Southeast Europe. With a strong emphasis on engaging local communities, this initiative focuses on identifying and prioritizing rivers for protection while highlighting their significant benefits to the local communities. Partnering with six organizations in Bosnia and Herzegovina, Croatia, Montenegro, North Macedonia, and Serbia, the initiative actively works to recognize, value, promote, and conserve free-flowing rivers in their respective countries, in close cooperation with decision makers. To bolster local capacity and empower partners, a Toolkit is under development as a learning and sharing platform to provide guidance for freshwater protection and management, accessible via the United for Rivers website. This platform will gather official documents, expert studies, national protection procedures, and more, offering practical examples of river protection processes. The initiative aims to protect more than 400 km of rivers by 2030, advocating for and enabling protection. The United for Rivers initiative sets a compelling precedent for the implementation of a Durable Freshwater Protection approach that can be replicated in other global regions.

Serbia: A war against rivers and activists

Iskra Krstic

Organisation for political ecology -- Polekol, Belgrade, Serbia

When it comes to Serbia, to say that the decline of democracy is threatening the environment in general and freshwater ecosystems in particular is an understatement. It's more accurate to say that the captured state has declared war on nature and the environmental movement. Two-thirds of the Serbian population recognise that "politicians, organised in interest groups, abuse power for the sake of their own personal interests". This has been documented in the case of the "epidemics" of mini hydropower plants in Serbia. It is madness to destroy free flowing mountain rivers, yet alone to sacrifice them for 2-4% of yearly electricity production on the national level. This doesn't bother the decision-makers, and the millions of Euros which flow into the pockets of investors with connections to state authorities through feed-in tariffs are presented as proof of lively economy. Unable to force the state to impose a national moratorium on MHPs, citizens-turn-activists have been fighting them one by one since 2014. An illustrative example is a struggle of the villagers in Dadince, South Serbia, helped by two activist organisations, who managed to prevent an illegal construction of a MHP on a river 15.000 people depend upon for drinking water. They were victorious – but not before the villagers spent four winter months on barricades. The further deterioration of political rights and civil liberties, and the rising pressure on independent media and civil society organizations put even such methods of struggle into question.

Implementation of environmental acquis relevant to hydropower projects in selected Western Balkan countries – Systemic failures and golden standards

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1 - ClientEarth, Belgium. 2 - Independent expert, Poland

The Western Balkan countries are required to implement various environmental acquis in relation to network energy under Energy Community Treaty. Furthermore, they are in the process of joining the EU. Albania, Bosnia and Herzegovina, the Republic of North Macedonia, Montenegro and Serbia are candidate countries and Kosovo is a potential candidate. The principle of the negotiations is that countries have to fully transpose and implement the EU's legislation by the time of accession, including Chapter 27 on the environment. We have conducted an analysis of transposition and implementation of six EU Directives: EIA Directive, SEA Directive, Environmental Liability Directive, Water Framework Directive, Habitats Directive and Birds Directive - all of which are relevant to hydropower projects - in selected Western Balkan countries. The analysis revealed both systemic failures to comply with EU environmental legislation and legal provisions that exceed the requirements of EU acquis, thereby serving as exemplary standards for the protection of rivers. One such notable example is the recognition of all hydropower projects (in Federation of Bosnia and Herzegovina) or those with a power capacity of 5MW and more (in Republika Srpska) as having a significant impact on the environment, making them subject to obligatory environmental impact assessments. Another noteworthy provision is the establishment of a list of reasons for rejecting the EIA report (in Federation of Bosnia and Herzegovina) which ensures legal certainty in the decision-making process.

Komarnica canyon, the screaming silence of untouched nature under threat – The battle for its preservation from hydroelectric power

Jelena Popović, Andrijana Mićanović

Montenegrin Ecologists Society, Podgorica, Montenegro

Komarnica Canyon is one of the last wild canyons of Europe. It has been protected on several national and international levels (IPA, IBA, Emerald candidate; potential Natura 2000). UNESCO proposed Komarnica to become part of the NWHS Durmitor. Komarnica is made out of five mountain rivers on the NW of Montenegro, that all together flow freely as big Komarnica through the canyon more than 30 million years old, surrounded by breathtaking villages on the high-plains above. This biodiversity hotspot canyon is threatened to be forever degraded by the plans of building large HPP, which would generate only 3.5% of Montenegro's annual generation of electricity. Generation of this amount of electricity while erasing the values of the area would cost more than 300 million euros. EIA that has been produced did not prove that Komarnica should be sacrificed, and is now in the process of the reassessment. Uniqueness, importance and values of Komarnica have gathered national and international scientists, experts on ecology, energetics, tourism, activists, artists, kayakers, fly-fishermen, other nature lovers and NGOs in order to raise awareness of Montenegrin and European citizens about Komarnica, its threatened status, and of the potentials of development of this area that are in line with principles of the ecological state and sustainable development. Two scientific expeditions, led by international scientists, have been conducted and undoubtedly showed main values of Komarnica Canyon. However, more scientific research is still needed for certain biodiversity groups in order to preserve this canyon from destruction.

E3 River restoration tools

Can't do them all, so how should we prioritize barriers for removal?

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Barrier removal can restore river continuity but resources available for defragmenting rivers are limited and a prioritization strategy is needed. Opportunities for barrier removal depend to a large extent on barrier typology, as this dictates where barriers are located, their size, age, and likely impacts. Crucially, river fragmentation depends chiefly on the number and location of barriers, not on barrier size, while the costs of barrier removal typically increase with barrier height. Acting on many small barriers will often be more cost-efficient than acting on fewer larger structures. Barriers are not randomly distributed and a small proportion of barriers have a disproportionately high impact on fragmentation, therefore targeting these 'fragmentizers' can result in substantial gains in connectivity. Barrier prioritization methods can be grouped into six main types depending on whether they are reactive or proactive, whether they are applied at local or larger spatial scales, and whether they employ an informal or a formal approach. While mathematical optimization sets the gold standard for barrier prioritization, a hybrid approach that explicitly considers uncertainties and opportunities is usually the most effective. To increase the success of barrier removal, we recommend that barriers slated for removal fulfil four conditions: (1) their removal will bring about a meaningful gain in connectivity; (2) they are cost-effective to remove; (3) they will not cause significant or lasting environmental damage, and (4) they are obsolete structures. Mapping barrier removal projects according to the three axes of opportunities, costs, and gains can help locate any 'low hanging fruit'.

RivConnect – A new tool for river network connectivity assessment

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River networks have unique characteristics that shape their functioning and freshwater species movement. The dendritic, hierarchic and directional nature of river networks has significant implications for connectivity analysis, having led to the creation of specific indexes. Nowadays, the impact of instream barriers and connectivity loss is widely acknowledged for freshwater systems so options to minimize or reverse connectivity impairment should be implemented, such as dam removal, dam retrofitting and/or the installation of fish passage devices. Connectivity analysis using graph theory is arguably the most consensual approach, but user-friendly tools are not generally available for stakeholders and decision-makers. Considering this we have created RivConnect, a new tool developed under the framework of Rivtool that focuses on calculating connectivity metrics for river networks. Like RivTool, it is a tabular-driven tool that uses segments as their minimum resolution unit of analysis. It allows calculating 15+ distinct connectivity metrics (e.g., Probability of Connectivity, Dendritic Connectivity Index, Integral Index of Connectivity, Betweenness Centrality), and for some, there is the option to use a boolean or probabilistic approach, asymmetric link values depending on the directionality and user-defined data to weight habitat value. Moreover, in comparison with other software, it reduces computation time and has no network size limitation being helpful for both single-basin and large-extent approaches.

Dammed fish: Impact of structural and functional river network connectivity losses on fish biodiversity – Optimising management solutions

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Rivers have always been linked to society development. Instream barriers are especially deleterious to freshwater dependent fish species that see their dispersion ability severely affected with possible consequences for population and species maintenance, altering genetic flow and community balance. With this in mind, the European Biodiversity Strategy has the specific goal of rehabilitating 25,000 km of free-flowing rivers. Additionally, the European Water Framework Directive (WFD) also determines that longitudinal connectivity re-establishment is vital to achieve the goal of good ecological status. To implement adequate measures for river network connectivity enhancement, connectivity has to be quantified at the basin scale accounting for the cumulative impacts of all the dams present in a given system. Dammed Fish is a Europe-wide research project aiming to evaluate and propose solutions and tools to inform river network connectivity management, to improve fish biodiversity and enhance the biotic quality of European rivers. The project is structured into five interconnected tasks to evaluate how dams, by themselves and combined with other pressures, affect river network connectivity, biodiversity loss, species range contraction and species turnover in (riverine) fish. Results will contribute to further research and improved management of river network connectivity by developing three free tools: RivFish—to link fish data and river networks; RivConnect—to calculate basin-wide network connectivity; and RivOpt—to optimize basin-wide connectivity management solutions considering conflicting management goals. Thus, Dammed Fish proposes an overall and integrative approach to connectivity management over large spatial extents.

Riparian zones – A key factor in conservation efforts for terrestrial and freshwater connectivity

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Riparian zones represent important transitional areas between land and freshwater ecosystems which provide a multitude of ecosystem services and support the objectives of several European directives and policy initiatives (e.g., Biodiversity Strategy (BS), Water Framework Directive, Habitats and Birds Directive). However, due to multiple anthropogenic uses, they are often highly impacted and restricted in terms of their expansion and dynamics. Based on the BS, more than 25,000 km of free-flowing rivers and their linked floodplains and wetlands have to be connected and restored by 2030. To reach that goal, strategies for prioritization, restoration and conservation are needed. Within the recently started Horizon Europe project "NaturaConnect", we combine spatial data from National River Basin Management Plans, Copernicus riparian zones and land-use data, IUCN red lists, protected areas and floodplains in a GIS-based modelling approach for the Danube-Carpathian region. This region comprises ten EU Member States and five neighbouring countries. With an integrative analysis, we identify multiple human stressors, biodiversity values and the current conservation status of actual and potential riparian zones and their biological assets. The detailed assessment of current threats can support the formulation of connectivity restoration activities to target BS goals better. Furthermore, the identification of riparian areas with high conservation value serves the protection of both freshwater and terrestrial ecosystems and contributes to securing an ecological network of green and blue infrastructures. Related results may be useful for implementing multiple EU directives and reaching biodiversity targets within the Danube-Carpathian region and beyond.

Tools to address the longitudinal connectivity in spatial freshwater biodiversity science

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Freshwater ecosystems are characterized by the unique feature of longitudinal connectivity among water bodies. Yet, this connectivity is largely neglected in spatial biodiversity analyses given the complex geospatial data processing steps. In addition, the sheer amount of geospatial data is considered a challenge, since such data can't be easily managed in a standard GIS environment. We have developed the R-package hydrographr (https://github.com/glowabio/hydrographr) that offers easy-to-use hydrographic processing tools, as well as the GeoFRESH online platform (http://geofresh.org/) that allows spatial queries across the network using a simple point-and-click interface. The R-package provides (i) basic functions for downloading and processing the high-resolution Hydrography90m stream network dataset, (ii) point processing tools for e.g. delineating catchments and annotating sampling locations with freshwater-specific data, and (iii) analysis tools which support stream network analyses regarding connectivity, distance and neighourhood that can be applied to calculate the fragmentation of the network. The GeoFRESH platform is considered complementary and provides a low-threshold entry for extracting environmental information across the network. We are furthering the process by including standing water bodies and expanding the framework also to the marine realm within a Virtual Research Environment, such that the entire aquatic continuum can be addressed in a single framework.

A4 Dam Removal – Large dams (Sponsored by McMillen)

Planning and implementation for the removal of the four dam complex of the lower Klamath project

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The Lower Klamath Project consists of four hydroelectric developments on the Klamath River located in the Western United States. The restoration of the Klamath watershed spans 15,000 miles of California and Oregon and is the largest dam removal project in history opening more than 400 miles of habitat. In September of 2016, the Klamath River Renewal Corporation (Renewal Corporation) filed an Application for Surrender of License for Major Project and Removal of Project Works (License Surrender). The Renewal Corporation filed the License Surrender Application as the dam removal entity for the purpose of implementation of the Klamath River Hydroelectric Settlement. In November 2020, the Renewal Corporation filed its Definite Decommissioning Plan which is the comprehensive plan to physically remove the Lower Klamath Project and achieve a free-flowing condition and volitional fish passage, site remediation and restoration, and avoidance of downstream impacts. Renewal Corporation received the Licensure Surrender in November 2022 approving facility removal and habitat restoration. The Proposed Action consists of the deconstruction of J.C. Boyle Dam/Powerhouse located in Oregon, and Copco No. 1 Dam/Powerhouse, Copco No. 2 Dam/Powerhouse, and Iron Gate Dam/Powerhouse all located in northern California. This paper discusses the planning effort and strategy developed and implemented to execute the project, including the organization structure of the Renewal Corporation designed to efficiently execute a multi-discipline engineering and construction project, challenges, and strategy to work through a vast regulatory process, and execution of a progressive design build contract to meet set project budgets and schedule.

Ecological restoration of the Selune River (Normandy, France) through the removal of two large dams

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The Selune River is one of the fourth coastal river that ends in the Bay of Mont Saint-Michel in Normandy, France. For over a century, two large dams hindered free water flow on its main course: La-Roche-Qui-Boit dam (16 m high) and Vezins dam (36 m high). Their dismantling was the subject of many political, ecological and societal debates before finally starting in 2017. After heavy sediment management and dismantling works, both dams were completely removed by the end of 2022. As a result, the upper 60 km of the Selune River, representing about 1000 km of flowing habitats, if one considers the numerous tributaries of the river, are now finally reconnected to the ocean. To follow the restoration of the Selune River, a scientific program was initiated in 2012. This multi-disciplinary program aims at characterising the physical, chemical, biological and societal processes involved in the ecological restoration of the river and its valley. In just a couple of years, results show that aquatic and riverbanks ecosystems are restoring quickly, leading to the improvement of the environmental status of the Selune River and its habitats.

Ecosystem response to the removal of the Elwha River dams, Washington State, United States of America

Keith Denton

K. Denton and Associates, Sequim, Washington, USA

We present results from the Elwha River, where the largest dam removal ever undertaken resulted in measurable ecosystem changes. A multidisciplinary, collaborative effort to study the effects of this large-scale dam removal has resulted in numerous studies and papers documenting the ecosystem level responses of this historic restoration act. This talk will synthesize the major findings and themes from over a decade of this work. The two dams were constructed in 1912 and 1927 and measured 33 and 64 meters in height, respectively. Their removal began in 2011 and was completed by 2014. The release and subsequent downstream transport of tens of millions of metric tons of sediment from the former reservoirs has resulted in the transformation and rebuilding of estuarine and riverine habitats. The resumption of free passage for aquatic organisms has re-established anadromous fishes to areas that have been void of such species for more than 100 years, prompting rapid increases in salmonid life history diversity. Large changes in sediment supply resulted in short term reductions in Chinook salmon productivity that have recently rebounded. Populations of steelhead, coho and pink salmon all have an increasing trend since dam removal. Following dam removal, marine derived nutrients from these increasing salmon populations has entered foods webs and altered the migration patterns and fecundity of an aquatic song bird. Our results demonstrate the critical importance of maintaining longitudinal connectivity for maintaining watershed processes and ecosystem services.

Monitoring the very first large-scale dam removals in Finland – Preliminary results

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River Hiitolanjoki in Finland is home of critically endangered landlocked salmon. It is also the first ever site in Finland to undergo large-scale dam removals over three consecutive years from 2021 to 2023. Our monitoring efforts are primarily centered on tracking alterations in fish habitats and the community's composition, as well as assessing energy transfer across multiple trophic levels as an indicator of ecosystem functioning. To achieve this, we employ a range of scientific methods, including physical habitat modeling, environmental-DNA (eDNA), traditional and boat-based electrofishing, and stable isotope analysis (SIA). Our monitoring initiative has been ongoing since 2020, enabling us to make comparisons between the conditions before and after each dam removal and the subsequent rapid restoration efforts. Based on our preliminary findings from 2020 to 2023, it is encouraging to observe the return of salmon and trout to a previously Cyprinus-dominated fish community, accompanied by increased variability in stable isotope ratios, which reflects changes in the food web structure. The project is conducted in multidisciplinary collaboration with Natural Resources Institute Finland (Luke) and Aalto University (AU). Changes in greenhouse gas emissions, social aspects of the dam removals (Luke), and hydraulics and riverine morphodynamics (AU) are also being investigated to provide a holistic picture of the impact of this large-scale dam removal and rapid restoration process.

Risk Management in Dam Removal

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Dam removal involves risks of adverse ecosystem impacts, cost overruns, schedule delays, and damages to third parties. In undertaking the largest dam removal in history, the Klamath River Renewal Corporation is using a systematic approach to risk management. It is a single point of accountability for performance, shielding its co-licensees, States of California and Oregon. It uses progressive design-build procurement contracts to allocate risks between contractors and owner. It holds a comprehensive insurance program against all insurable events, including damages caused by sediment transport from the lowermost dam site > 190 miles to the Pacific Ocean. And this insurance program is backstopped with bonds and indemnities. In sum, this approach to risk management will contribute to successful dam removal, on time and budget.

B4 Small scale fish passage solutions

Fish migration passages on smaller watercourses: How effective are they?

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The last few decades more awareness on the importance of free fish migration has been raised, especially since the start of the EU Water Framework Directive. The province of East-Flanders (Belgium), being an important water manager of more than 1500km of watercourses on its territory, has been constructing several fish passages to allow free fish migration during the last years. In order to check the effectiveness of these different types of fish passages conventional research with fykes as well as an underwater camera has been used. The results indicate that most if not all species present in the study site (large as well as small species and juveniles as well as adults) could pass nature-based passages as well as more technical man-made passages. Monitoring with underwater cameras allows insight in fish behaviour and revealed in the past that certain fish avoid fykes, while a camera does register these fish. In general, more species could be detected with a lower effort when using a camera combined with artificial intelligence to automatically recognise species. The disadvantage of these cameras is the lack of detailed data on the size distribution and weight of the species as well as the somewhat more technical challenges. We can conclude that besides river restoration, the construction of fish passages has a positive effect on fish communities and helps to reach the goal of free fish migration.

Improving fish passage by an unstructured block ramp

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Within the development of TIWAG "Speicherkraftwerk Kühtai" HPP the ecological restoration at weir Brunau is a main compensation measure. At the existing weir, fish migration will be provided by construction of an unstructured block ramp (UBR). Additional to the high specific design flow, the river bend as well as existing diversion facilities are challenging topics in the design stage. Hydraulic investigations were made using a commercial 3D numerical model including the Volume of Fluid (VOF) method for free surface representation. A 3D simulation is essential here because of the location of the unstructured block ramp at the end of a river bend and a secondary flow situation there. Regarding secondary flow pattern in river bends, numerical results were evaluated according to the findings of research-projects on typical flow situations in river bends (University of Innsbruck, 1986 – 2002). Results of several different investigation methods show good agreement thus proving the reliability of the hydraulic simulation. Due to the fact, that a UBR type ramp matches the natural river morphology of the Ötztaler Ache in Brunau best, high durability concerning fish migration as well as operation of the diversion facilities and ramp stability will be provided. A recent flood event affecting the project area has proven the stability and durability of the chosen solution.

From theory to practice with naturalized design

Arantxa Unzurrunzaga

Gipuzkoa Conty Council, Donostia, Spain

In the 19th century, a mill was built on the River Sarobe. It is in a section where the river is divided in two, so we decided not to touch the dam and consolidated one part. If an obstacle can´t be removed for an archeological reason, a good option is to consolidate one section of the river. In which case it is necessary to study if the flow passes from that section without potentially causing flooding. It has to be possible for fish to pass and at the same time, the consolidated section has to look natural. That is the solution we found. The area is full of trees and there are fish like Salmo salar, Salmo trutta m. fario, Piscardo, Phoxinus bigerri, Barbatula quignardi, Anguilla anguilla. With this solution, there is flooding risk, so it is necessary to study and prevent this and yet allow fish to pass. For these two reasons we simulated with Hec-Ras the level of water and we follow the established in «Fishpasses – Design, dimensions and monitoring» (FAO / DVWK - 2002), the English version of the German manual to allow fish to pass.

Risk assessment for fish passing turbines, pumps and hydraulic structures: A methodological framework and innovative methods

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The RETERO project has developed a framework for assessing injury and mortality risks in fish as they pass through turbines, pumps, and hydraulic structures, providing improved methods. The primary objective is to replace or significantly reduce the reliance on live fish testing. Phase I of a site assessment involves considering site-specific and stakeholder constraints for method selection. In Phase II, a combination of numerical and experimental techniques, completely avoiding live fish experiments, is used to predict the mortality risk. In cases of very low or high mortality rates, live fish testing is deemed unnecessary and ethically inappropriate. Live fish tests are only considered in situations where medium mortality rates near desired thresholds demand a third-phase evaluation, providing reliable data on the mortality or injury risks to target species. The newly developed RETERO methods offer two types of alternatives to live fish testing. Numerical methods are based on a probabilistic approach and virtual fish simulations, employing a Newtonian methodology. Experimental methods include both passive and active probes. Furthermore, non-invasive biologgers have been designed to collect data on the physical conditions of the fish's environment. These biologgers can reduce the number of fish needed for live fish experiments by providing additional data, allowing for the analysis of environmental parameters and the assessment of causes of injuries or mortality. The methods integrated within the framework aim to minimize the number of animals required for evaluating the mortality risk in turbines, pumps, and hydraulic structures, while enhancing the quality and reliability of assessment results.

An Archimedes screw threesome: A study evaluating the fish friendliness of three Archimedes screw variants

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Habitat connectivity is essential for fish populations. Nevertheless, their movements are often hindered by hydraulic structures such as pumping stations. To safeguard fish populations safe passage through pumps is required. Previous studies have shown that fish pass Archimedes screws with half-open housing with biologically significant injuries. In this study we quantified and compared fish safety at three variants of the Archimedes screw: the half-open Archimedes screw without and with rubber strips and the Archimedes screw with a closed housing. The injury and mortality were evaluated during downstream passage through these three screw types for the critically endangered European eel (Anguilla anguilla) and roach (Rutilus rutilus) in conjunction with two types of sensors (autonomous barotrauma detection sensors and fish backpack sensors). For both species, the closed Archimedes screw had the highest survival and lowest injury probabilities. In addition, rubber strips on the half-open Archimedes screw significantly lowered the injury rates and hence improved survival of both eel and roach. The postulated biologically significant injuries at the half-open Archimedes screws without rubber strips was again confirmed. BDS and backpack sensors revealed that the passage through the screws is a chaotic event, and no single passage showed the same empirical pressure distribution. In summary, the possibility for grinding injuries, i.e. when fish are squeezed through narrow gaps between the flights and the concrete trough, was confirmed at the half-open Archimedes screw without rubber strips but can be reduced with rubber strips. The safest passage was proven at the closed Archimedes screw.

C4 Cultural and socio-economic aspects of free-flowing rivers

Uncovering the invisible connection between people and rivers

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Around the world, rivers are linked to socio-cultural values such as identity, education, sense of place, and beliefs. These connections between locals and rivers are essential to understand how to stop, adapt to, and revert the effects of human-induced changes on rivers. However, riverine socio-cultural values are difficult to include in river management processes because they are not directly quantifiable. In this contribution, we bring together experiences that look into understanding and mapping riverine socio-cultural values and the perception of river-related risks (both from and to the river). Using a transdisciplinary approach including questionnaires, interviews, a map-based approach as well as evidence-based data on land and water use, biodiversity and risks, we explore how the perception of such values can influence water resources- and decision management. We present research on free-flowing and restored rivers including Tagliamento (Italy), Soča/Isonzo (Slovenia/Italy), Upper Neretva (Bosnia-Herzegovina), Rönne Å (Sweden) and Taquiña (Bolivia) rivers, exploring different ways of relating to nature and how these affect socio-cultural values and risk perceptions. We look into differences and commonalities among free-flowing and more managed rivers in light of conflicting values, such as risk management, energy production and land use impacts on water resources and biodiversity, and transboundary water issues. Identified positive interactions between cultural values and management issues can lead us towards a river management that is centered around local communities, and is based on observation data.

Mainstreaming NbS in water management sector – Example from Croatia

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Croatia has experienced severe floods, causing damage to infrastructure, significant economic loses and devastating people's lives. It has also seen droughts, inflicted agricultural losses and putted pressure on drinking water supplies. These extreme weather events are only expected to become more common and severe as climate change advances. At the same time Croatia struggles with water quality challenges in some catchments due to poor levels of wastewater treatment. The European Investment Bank and The Nature Conservancy have entered into a partnership to help Croatian stakeholders identify what role Nature-based solutions (NbS) could play in addressing these issues by filling knowledge gaps around the types of NbS that could be deployed in specific catchment as well as the broad technical, legal, and governance characteristics of the NbS that need to be in place to enable investment. The recommendations point to actions required to accelerate and scale up successful implementation of NbS in Croatia to address water security while deliver broader protection and enhancement of freshwater habitats and species.

Ecosystem services for dam removals in the River Lahn (Germany)

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The ecosystem study aimed at creating two hypothetical scenarios for alternative future developments of selected dams of the River Lahn. The study intended to quantify the respective impacts on ecosystem services and to complement this information with monetary valuations as far as possible. Thereby, both conventional biotic ecosystem services such as water retention, recreation and habitats as well as abiotic services, primarily the use for navigation and hydropower, were considered. The research reported here represents one of the first systematic, quantitative and economic valuations of hypothetical dam removal projects in Germany. Scenario 1 assumes that navigation and hydropower persist on the River Lahn. The ecological continuity is established at the dams through technical installations. Scenario 2 is characterized by reestablishment of natural hydro-morphological conditions at a larger part of the adjacent floodplain, dam removal and river bed levelling. Both scenarios were then compared for three selected dams in the River Lahn. Property issues, legal considerations as well as technical and financial implementation costs were disregarded in this hypothetical scenario study. The costs of dam removal and restorations in scenario 2 would be compensated by the high societal benefits from increases in ecosystem services values. The comparison of scenario 0 to scenario 1 reveals that the adaption of only technical properties isn´t distinctively effective in terms of ecosystem services. Scenario 2 shows significant increases in ESS to the current situation and therefore should be considered more frequently in river restoration concepts.

Art as water management

Kelsey Aho

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Scientists and managers share their river findings visually and orally through presentations and written publications. I will share findings kinesthetically, making space for the audience to use their hands to restore our relationships with rivers. After visiting clay mines a decade ago, I began using my hands to collect clays, sediments, and silts. Residents, researchers, land managers alike have shared pieces of their yards, favorite trails, and research samples (e.g., permafrost cores) with me. Each piece of earth is added to a data dictionary and public web map before being wedged, low fired (900 °C), glazed, and fired again (1000–1200 °C). Then, in what challenges my own understanding of "place", I can place a piece of a Balkan river or an Alaskan glacier in someone's hand. As they move their finger along the edge, I can ask whether it feels like the river from their hometown or whether they think it feels more like silk or a sponge. In this session at the Free Flow conference, we can use our hands to build policy, scientific, and emotional relationships with rivers. I will encourage the audience to engage kinesthetically with the session. In addition to visual images and audio stories, the rivers will be physically present in this session. This session can share the texture of the rivers near and far from Oosterpoort. This session is appropriate for all ages, experience, and types of learners.

D4 Priority actions towards free flowing Rhine and Maas rivers (Sponsored by Arcadis)

Connectivity on the River Meuse

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Longitudinal and lateral connectivity within fluvial ecosystems is important for ecological diversity. Especially mobile organisms such as (migratory) fish are hindered substantially to complete their lifecycle due to in-river structures such as dams, sluices and weirs. Bound also by international legislation such as the Water Framework Directive (WFD) and the EU Habitats Directive, it is vital to provide adequate solutions to improve connectivity so that habitats for spawning, nursing and feeding are no longer isolated. The Meuse is such an impacted river system, in the Netherlands fragmented by seven sluice/weir-complexes, two of which encompass a hydropower-station as well. Each of the complexes are equipped with a fish pass. In the past evaluation of these facilities was done by fyke fishing. Although quite a lot of fish species and length classes were caught, efficiency was still difficult to estimate. With the increasing use of telemetric methods for long distance migrants a better understanding of connectivity for upstream and downstream migration on the River Meuse was gained. It can be concluded that there is still a long way to go to reach a state of connectivity that is necessary for thriving populations of these long-distance migrants.

Connectivity in the River Meuse: Characteristics of a major, flowing bypass

Jeroen Tummers, Jasper Arntz

Arcadis NL, The Netherlands

Habitat fragmentation and the resulting lack of lotic, free-flow conditions is a major factor impacting ecological quality elements in watercourses. The River Meuse is such an impacted river, naturally containing a diverse mix of flow conditions, substrate types and sedimentation processes. However, between 1915 and 1942 seven sluice-weir complexes were constructed to facilitate shipping traffic, but this severely limited longitudinal connectivity for aquatic biota. The ponded sections in between the complexes lack habitat heterogeneity, especially diverse substrate and flow conditions, thereby impacting species protection goals for (aquatic) life. To create more flowing habitat in the Meuse, and to alleviate the impact on hydromorphological processes of the sluice-weir complexes, a major bypass is being designed at weir Sambeek. This 3.2 km long natural channel will bypass the weir and realize a double-sided connection on the right bank directly with the Meuse. The bypass is designed to contain a natural gradient of substrate particles (gravel, cobble/pebble beds) and a range of flow conditions. With protected, listed species in the Meuse and connected lateral waters comprising in part rheophilic species, the current bypass will provide habitat for spawning, nursery and foraging. Bound by national and EU legislation such as the Water Framework Directive, restoration of natural, historically available habitat in the Meuse is promoted by implementing this bypass, thereby aiding in the recovery of endangered, endemic species. What are the ecological requirements of target species for this bypass, and how do aquatic biota benefit from the bypass in the wider Meuse system?

Ecological continuity of weir complexes for fish in the Water Framework Directive Explorer

Sam Maijvis, Valesca Harezlak, Erik Ruijgh

Deltares, Delft, Netherlands

Reduced ecological continuity due to weir complexes can seriously hamper fish migration and as such impact biodiversity. To gain a better insight into the fish passability of weir complexes, Deltares developed a tool to quantify the loss of fish at weir complexes in the Meuse and Lower Rhine based on the characteristics of the present hydraulic structures, river discharge, fish species and the direction of the migratory movement. The quantification of these losses is based on literature and expert judgement. To combine information on the passability of various types of weir complexes with habitat suitability of water bodies (and thus the ecological relevance for fish to reach a certain water body), the tool has been coupled to the decision support tool Water Framework Directive (WFD) Explorer. The WFD Explorer focusses on the habitat suitability of WFD water bodies for, amongst others, the different life stages of fish species. The WFD Explorer did not yet distinguish between different types of hydraulic structures and considered all weir complexes as equally detrimental. The present improvement allows for the analysis of the passability of current and future weir complexes and discloses the ecological value of the waterbodies that are confined by these structures. To facilitate conversations between civil engineers, ecologists and policy makers, the results of this coupling are presented on an insightful map that shows the possible consequences of the choices made during the design of new and/or the renovation of existing weir complexes.

Rhine salmon population threatened by multiple hurdles along their migration

Jacco van Rijssel (1), Erwin Winter (1), Joep de Leeuw (1), Tim Vriese (2)

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Freshwater species biodiversity is under threat. The average global decline for migratory fish species is estimated to be more than 75% since 1970. Atlantic salmon is one of these species and has an estimated decline of 99% in the River Rhine. The causes for past decline have been posted to habitat loss, pollution, climate change and overfishing. In this presentation, we lay out the recent further decline, estimate losses of smolts and adults at different sections in the freshwater habitat and elaborate on potential causes of the decline and these losses. We found that the salmon population of the River Rhine has declined rapidly over the past two decades with a current estimated spawning population of only 373-798 individuals. Far from the desired 3% supposedly needed to maintain a self-sustaining population, this equals a percentage of salmon returning to the spawning grounds of between 0.5-0.6%. Many individuals disappear during their migration, with the highest percentage of smolts disappearing in the German tributaries (44%) and the Dutch lower Rhine (71%) while the percentage of disappearing adults is highest in both the Dutch (74%) and the German (78%) Rhine. Causes of the decline per river section remain unclear and possible threats, some specific to the River Rhine, are being discussed. Predation in combination with migration obstacles seem to be a likely culprit. To ensure that the highest number of wild smolts in the best condition leave the Rhine for the ocean, management needs to restore the ecological capability of the Rhine system.

Free flowing rivers in The Netherlands

Gerard Litjens (1), Bas Roels (2), Bart Beekers (3), Daphne Willems (1)

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The Waal River is the main branch of the 600 km free flowing Rhine River ecosystem, entering The Netherlands in the Gelderse Poort area at the German border. It is a heavily influenced and narrowed river system and, in many ways, far out of balance, thus causing more and more troubles for both the river management and nature management. Between 1990's and now already 25.000 hectares of riverine nature is being restored, leading to the return of beaver, black poplar, see eagle and salmonids in the river area. The international successful Living Rivers project originates from here and it's still of major concern for the WWF-NL and its partners. The challenge is to a full re-establishment of the river nature of about 70.000 hectares in the next 25 years. An ambitious plan is to do this by integrated river management, using natural solutions. Ten free flowing side channels: A series of ten free flowing side channels and redesigned river forelands with lowered summer dikes are meant to further restore the natural river dynamics at 30 to perhaps 50 km of the Rhine River. This might lead to a number of advantages for nature and society.

A5 Large scale fish passage solutions (Sponsored by CDM Smith)

Fish migration river: Nature based large scale fishway between Waddensea and Lake IJssel. Under construction now! Adaptive design, construction and research ambitions

Erik Bruins Slot (1), Katja Philippart (2)

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Many estuarine barriers were built worldwide. These barriers decreased ecosystem functioning and connectivity for fish. In 1932, a large barrier was constructed in the former estuary Zuiderzee that connected the Waddensea with River Rhine. As a result, estuarine habitats disappeared and fish migration from sea to freshwater is obstructed. Diadromous fish strongly rely on incoming tidal currents for their upstream migration by using Selective Tidal Stream Transport. Water management protocols do not allow for salt water intrusion into fresh water Lake IJssel. Upstream passage is restricted to small temporal windows during discharge events with water currents surmountable only for strong swimmers. To restore fish migration between the Wadden Sea and Lake IJsselmeer a uniquely designed fish passage has been developed called the 'Fish Migration River' (FMR). This fishway is an artificial river of kilometres long incoming and outgoing tidal currents and enables diadromous fish. It's the example of innovative nature based Dutch Delta Water management 21th century. A large-scale fish passage to recover fish populations as a link in the food web and biodiversity. Construction has started and is to be completed in 2025. An abiotic and biotic monitoring program will evaluate and optimize the future functioning of FMR. See this next step in ecologic engineering after opening the other front door in the Rhine 'Haringvlietdam' and creating new fish habitat Markerwadden. Focus on Construction and Climate adaptive Design of the system, Research & Monitorings program during construction, try-out and operation: life cycle approach of our migrating fish.

Severn Unlocked? The response of two anadromous fishes to catchment-scale barrier mitigation in the River Severn revealed using acoustic telemetry

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Programmes to remove or mitigate riverine barriers are increasingly used to improve the passage rates of migratory fishes in lowland rivers, enabling individual fish to range more freely over larger areas of river. In the impounded lower River Severn basin, western Britain, a programme of weir modifications ("Unlocking the Severn"), including fish pass construction, was completed in 2022. The result is that anadromous twaite shad Alosa fallax and sea lamprey Petromyzon marinus can now potentially more easily access spawning areas in the middle and upper catchment. Using acoustic telemetry between 2018 and 2023, we tracked the spawning migrations of 353 iteroparous shad for up to three consecutive years, and 128 semelparous sea lamprey for single years, to assess the effect of this reconnection on the spawning migrations of these threatened species. In the presence of the weir modifications, individuals of both species were able to pass weirs at lower flows than pre-modification, and more easily reach upstream spawning areas. However, the proportion of the species moving upstream of these weirs remains low, especially for shad, despite relatively high numbers of fish in river reaches immediately downstream, thus population-level responses are not yet apparent. Therefore, while both species can now move more freely through the river than prior to re-connection, their initial responses to this improved access to upstream spawning areas remains limited due to the relatively low proportions of individuals currently passing through these novel structures.

Horizontal fish screen solution for downstream fish passage at a historic dam used to restore Lahontan cutthroat trout population

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Derby Dam, located on the Truckee River outside of Reno, Nevada USA, is the oldest capital project owned and operated by the U.S. Bureau of Reclamation. The dam was built in 1905 without provisions for upstream or downstream fish passage. This has blocked access to fish spawning and rearing habitat for Lahontan cutthroat trout (Oncorhynchus clarkii henshawi) and a sucker fish known as cui-ui (Chasmistes cujus). Both fish species are endemic to the Truckee River and are listed under the U.S. Endangered Species Act. To restore aquatic connectivity and provide fish passage around the dam, a three-part fish passage project was planned. First, an upstream fishway channel was designed and constructed. Second, selected gates on the dam were replaced to provide more control of the water elevation in the forebay of the dam. Third, to complete the fish passage project, a horizontal fish screen facility was designed to safely pass fish downstream of the dam and away from irrigation water. The facility includes an array of Farmers Conservation Alliance patented horizontal fish screens, designed to accommodate up to 600 cfs (the largest horizontal screen project in the world). Project development included advanced hydraulic modeling, with a computational fluid dynamics model coupled to a physical prototype to help verify the proper hydraulic functioning of the project. This talk will focus on the third and final part of the fish passage project and will include an expanded background, an introduction to the FCA screen system, design development, engineering challenges, and construction updates.

FishPass – A vision for selective fish passage solutions to the connectivity conundrum

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1 - Great Lakes Fishery Commission, TRAVERSE CITY, USA. 2 - Great Lakes Fishery Commission, Ann Arbor, USA

Selective connectivity – passing desirable species while blocking undesirable species – could provide a solution for restoring connectivity in rivers fragmented by barriers while not compromising on-going management of undesirable and invasive species. The Great Lakes Fishery Commission and its partners are developing an approach to selective fish passage that integrates fish ecology and biology with engineering at FishPass. The FishPass project will replace the last of four legacy barriers on the Boardman (Ottaway) River, Traverse City, Michigan, USA with an improved barrier and adaptable fishway designed to develop and test tools to selectively pass desirable fish while blocking and/or removing undesirable fish, like the invasive sea lamprey. The process used to select and configure fish sorting tools will follow an eco-engineering approach inspired by material recycling, and emphasizes automation and the integration of multiple technologies that target sortable phenological, morphological, behavioral, and physiological attributes of fish. FishPass will operate as an adaptive management project where researchers will annually assess fish communities and habitat use above and below the facility, apply different treatments to optimize fish sorting and passage efficacy, and on the basis of results adapt operations to maximally benefit the watershed and accommodate stakeholder desires. Herein, we provide an overview of FishPass including the ongoing research supporting selective fish passage and its adaptive management.

Ulrike Drabek: Nature-based solutions for fishways

Walter Reckendorfer, Ulrike Drabek, Roland Schmalfuß

Verbund Hydro Power GmbH, Vienna, Austria

Improving the conservation status of fish species listed in Annex II of the Habitats Directive requires a systematic approach that prioritises habitat creation over mere passability. The most important habitats for our native river fish are shallow gravel bars, which provide spawning and juvenile habitat. Dynamic bypass channels can both provide these habitats and be used as migration corridors. Against this background, VERBUND has carried out several renaturation projects, partly funded by the LIFE programme, which were also accompanied by research projects. As part of these research programmes, we have tagged fish in the tailwater and reservoir of the HPPs with PIT tags (Passive Integrated Transponder). PIT antennas mounted in the fish pass permanently detect the tagged fish and allow us to estimate the use of the pass for upstream and downstream movement and seasonal habitat use. Our research extends the understanding of the potential of nature-based solutions for habitat provision and bidirectional movement by investigating their efficiency in run-of-river hydropower plants on the Danube.

B5 River restoration tools

Prioritizing barrier removals in Germany - a GIS and feasibility approach

Ruben van Treeck, Sigrun Lange

WWF Germany, Berlin, Germany

Germany's rivers are clogged. At least 200,000 barriers disrupt longitudinal connectivity, displace and degrade riverine habitats, and cause deterioration of water quality. Many of these barriers are in use, and with no prospect of being dismantled soon, but a large share of them very well could be. But which are the ones? And are the ones that can be removed also the ones that promise the biggest ecological gain? For the first time on national level, WWF Germany led a project to map barriers that meet both these criteria that are arguably the most critical ones when prioritizing restoration efforts in a combined approach using GIS and surveys among the responsible authorities. GIS-parameters included the potentially reconnected upstream length and the hydro-morphological state of the reconnected stretch, the location and the density of the barriers within the basin. Feasibility surveys included (but were not limited to) questions about use, structural integrity and expiring concessions of the barriers that ranked high on GIS-criteria. We found that out of around 52,661 barriers suited for the GIS evaluation 787 withhold great ecological potential, with their removal opening more than 26,000 km of freely accessible river stretches. Feasibility surveys further narrowed down and complemented the selected barriers greatly. The resulting portfolio aims to present high-priority objects across Germany, showcase promising areas and capacity for holistic, large-scale restoration programs and catalyze further initiatives that address improvements to river connectivity.

"River pearl"-label as driver for dam removal?

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In the past, rivers in Germany were altered dramatically. They were straightened, dyked and fragmented by many transverse structures to gain agricultural land, prevent flooding and produce electricity. Consequently, 54% of the German rivers are "heavily modified" or "artificial". Of the remaining "natural" rivers, only 13% show a "good ecological status". More than 20 years after the adoption of the Water Framework Directive, you will hardly find any near-natural river stretch in Germany, not fragmented but characterized by natural watercourse structures, unregulated water flows and intact bedload balances. Authorities often do their best to restore freshwater ecosystems, but are hindered by several obstacles, such as eternal rights, political priorities, or insufficient resources. Supporters, emphasising the value of free-flowing rivers, addressing the lack of continuity, and promoting the removal of obsolete or harmful barriers, are mostly welcome. Currently, WWF Germany introduces the "River pearl PLUS" label for near-natural river stretches. Those river pearls must comply with eight criteria that define the near-natural state. To preserve river pearls for the future, local stakeholders are encouraged to develop a plan with measures to protect and even improve their river. The label is intended to raise awareness of the threats to water bodies, to fill people with pride and motivate them to free their river from barriers. Apparently, the idea works: Initial discussions with responsible parties for the first candidate brought together officials from different public authorities. During the exchange, three weirs that might be dismantled have already been identified and next steps defined.

Are satellite images reliable for filling barrier data gaps? Modelling barrier discovery to achieve free-flowing river targets

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Fragmentation caused by artificial barriers is one of the main stressors of rivers worldwide; however, reliable information on barrier numbers is difficult to obtain, and most studies grossly underestimate barrier numbers. To meet the targets of the EU Green Deal Agenda, at least 25,000 km of rivers need to be free-flowing by 2030, which requires good knowledge of the extent of fragmentation. Remote detection of barriers via satellite imagery can overcome barrier data deficiencies but its accuracy has seldom been tested. We modelled the accuracy of remote sensing for identifying instream barriers by comparing barriers identified via river walkovers with those detected from satellite images using Google Earth. Using satellite imagery, we were only able to detect 48% of known barriers but our model was able to predict whether a barrier could be detected remotely or not with 72% accuracy. The probability of barrier detection from satellite images decreased with altitude and forest cover, increased with stream order and also varied with barrier type and type of survey. Observer skills affected the ability to locate barriers remotely and detection rate varied by 11% between experienced and less experienced observers, suggesting that prior training might improve barrier detection from satellite images. Our study suggests that although remote sensing alone cannot fully substitute 'boots on the ground' field surveys for filling barrier data gaps, it can reduce the amount of field work necessary to improve barrier inventories and help inform optimal strategies for dam removal under data-poor scenarios.

A method for fish meta-population connectivity evaluation and barrier removal optimization

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Connectivity is a critical component in determining species distribution and meta-population dynamics by regulating the movement of organisms between resource habitat patches along river networks. Human-made obstacles (dams, weirs, culverts, etc.) cause a high degree of fragmentation of rivers networks, resulting in severe ecological impacts. In the last decades, several methods have been developed to assess the connectivity and optimize barrier removal programs. However, most of these tools focus on structural river connectivity (i.e. the connectivity between all river reaches on a catchment regardless of the species that live in them). By contrast, functional connectivity (the movement of a given organism through different habitat patches) has received less attention due to the general lack of knowledge about freshwater organism movement and behavioral ecology. Freshwater fishes are especially affected by river fragmentation and numerous local and global fish extinctions have been recorded around the globe due to this cause. This sensitivity is associated with their size, migratory behaviors, and strictly aquatic life cycle. In this work, we present a connectivity index for measuring fish meta-population connectivity that considers river network structure and cumulative barrier passability. In addition, we show the results of applying it to different Iberian fish species meta-populations and how this can guide barrier removal programs based on population connectivity maximization.

Estimating fish habitat fragmentation patterns and simulating barrier removal to target habitat restoration efforts

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A common global aim for the conservation of freshwater systems is the restoration of river continuity. For example, by strategically eliminating river barriers, the habitats for freshwater biodiversity and the longitudinal connectivity of the stream network can be improved. Here we propose and apply a workflow to 1) use fish species occurrence information to calculate along the network distance connectivity indicators, 2) use the output of species distribution models to estimate the potential distribution habitats of fish species along the stream network, 3) calculate the status of fish habitat fragmentation given the current set of barriers, and 4) run a simulation exercise to investigate improvements of fish habitat connectivity by systematically removing barriers in the network. As a test study case for the analyses, we will use the biological, environmental and river network data available for the Júcar watershed in Spain. We will also employ for the first time the recently developed high-resolution Hydrography90m dataset. It consists of a detailed stream network including the stream segments located in upstream areas, which are repetitively ignored in freshwater biogeographical studies. With this, we expect to produce more accurate estimates of fish habitats and river connectivity. The results will highlight the potential priority areas that could be targets for freshwater habitat restoration.

C5 River restoration for LIFE (EU LIFE projects)

River restoration for a free flowing Rönne å River – Challenges and lessons learned

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Rönne å River is the most southerly salmon river in Sweden. Today the spawning is dedicated to the lower parts of the river due to the three large migration barriers in the main stem blocking fish migration and species distribution. Upstream of the barriers there are fragmented freshwater pearl mussel and thick-shelled river mussel populations without any recruitment. The barriers also have a negative effect on the hydrology and there is no natural transportation of sediments to the sea causing erosion problems and changes in the ecosystem. In LIFE CONNECTS the three hydropower plants will be dismantled and the river will become free flowing again after more than 70 years. Together with habitat restorations this will give potential for an increased production of salmonid fishes as well as the threatened European eel, lamprey species and the host fish species for the mussels. The restoration actions will also have a positive impact on several ecosystem services through increased recreational values, angling tourism, coastal sand deposition, climate adaptation and much more. The process to remove three large dams includes many steps with their specific challenges and time needed. In this presentation we will give you a brief insight in a larger dam removal project and the lessons learned during the planning process until the actual implementation.

Restoration of fish migration and beginning of a European sturgeon recovery project in the lower Ebre River (Catalonia) and beyond

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The LIFE MIGRATOEBRE project (2015-2024; www.migratoebre.eu) aimed to improve fish migration in the lower Ebre River (Catalonia), mostly focused on Anguilla anguilla, Alosa fallax, Petromyzon marinus and Acipenser sturio conservation and recovery. Several mitigation measures have been executed, such as the construction of several fish passage projects (at Ascó and Xerta weirs). Various studies (such as mapping of aquatic habitats) and a regular monitoring (water quality, fish populations) has been done. Between 2017 and 2020, 150 fish (10 Chelon ramada, 13 Chelon labrosus, 21 Mugil cephalus, 45 A. fallax and 61 A. anguilla) were monitored by acoustic telemetry. To reinforce this information, in autumn 2023, 45 juveniles of A. sturio transported from Saint Seurin-sur-l'Isle (Nouvelle Aquitaine, France) were also marked and released in the lower Ebre River. Obtained results indicate that Ebre River allows the recovery for those endangered species. From now on, it is planned to develop a restoration plan for the species in the Iberian Peninsula, based on the Action Plan for the conservation and restoration of the European sturgeon and on the Technical Guidelines for the development of reintroduction programs of wild species in Spain (MAGRAMA, 2013). This work was funded by the LIFE MIGRATOEBRE Project (LIFE13 NAT/ES/000237; 2014/07/01 - 2024/06/03), the Institute for the Development of the Ebre Regions (IDECE), and the Catalunya - La Pedrera Foundation. It also received support from the Research Unit EABX - Aquatic ecosystems and global changes from INRAE Nouvelle-Aquitaine-Bordeaux.

Overcoming challenges and constraints to delivering effective river restoration: Lessons learnt in the Four Rivers for LIFE project

Susie Kinghan, Peter Jones, Leila Thornton, Duncan Dumbreck

Natural Resources Wales, United Kingdom

Four Rivers for LIFE is a large-scale river restoration project focusing on four rivers in south Wales: Afon Teifi, Afonydd Cleddau, Afon Tywi and river Usk. It is a collaborative project led by Natural Resources Wales. The rivers are of international importance for species such as Atlantic salmon, lamprey, shad, bullhead, freshwater pearl mussels, otter and water crowfoot. However, all are currently in unfavourable condition due to multiple pressures including land use impacts, barriers to migration, morphological modifications, and invasive species. This £9 million "catchment scale" project runs from 2021-2026. Project aims are to improve the condition of the rivers and boost populations of the key species. Actions include advising on best practice farm management and creating riparian buffer strips, improving river connectivity, in-channel habitat restoration, river re-meandering, floodplain re-connection, re-establishing populations of critically endangered freshwater pearl mussels, and controlling invasive species. We will discuss project progress so far, particularly focusing on the challenges encountered in delivering river restoration works, as well as the lessons learnt in overcoming these hurdles. One of the major challenges has been the public's perception of rivers. We argue that changing peoples' mindsets regarding the natural state and functioning of rivers is key to achieving meaningful long-term river restoration. The project is funded by the EU LIFE programme, with additional finance from Welsh Government and Dŵr Cymru Welsh Water. With Natural Resources Wales the lead partner, project partners include: the UK's River Restoration Centre, Coleg Sir Gar, Bannau Brycheiniog Park Authority, and Woodland Trust.

TRIWA LIFE - The Torne River International Watershed LIFE – Europe's largest water project

Sofia Perä

The County Administrative Board of Norrbotten, Luleå, Sweden

TRIWA LIFE is a cooperation project between Sweden and Finland that aims to restore habitats in streams and wetlands that are affected by human activities within the Torne River catchment area. The Torne River forms the boundary between Sweden and Finland. The Torne River, with tributaries, has been used for timber floating. To facilitate the timber floating, streams were straightened and cleared of boulders and dams were built, hence destroying habitats, and creating migration barriers. When the timer floating ended, many forestry roads were built to transport the timber by trucks. With the roads came new problems, i.e., road culverts that can be migration barriers. Many wetlands have been ditched to created forest- or agricultural land. This has destroyed the hydrology and the habitats of the wetlands. Our objectives are to restore 100 kilometres of streams, remove 399 migration barriers in streams and restore 2 500 hectares of wetlands within the Torne River catchment area. The project will recreate natural habitats for all species in the targeted streams and wetlands, for instance salmon, otter, and brown trout. The project TRIWA will continue between 2023-2030 and it will contribute to reach the goals of the Water Framework Directive and improve the status according to the Natura 2000 directives. TRIWA has a budget of 21 million Euros. The project is funded by the European Union's LIFE programme. Views and opinions expressed are however those of the authors only and do not necessarily reflect those of the European Union or CINEA.

LIFE IP IRIS – Integrated River Solutions in Austria – Linking Water Framework Directive and Floods Directive

Helena Mühlmann, Martin Wenk

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The Integrated LIFE Project 'IRIS – Integrated River Solutions in Austria' supports the national implementation of both the Water Framework Directive (WFD) and the Floods Directive. By applying a catchment-based, integrated planning approach, IRIS seeks to replace conventional water management strategies with more sustainable practices. Currently, about 55% of Austria's rivers fall short of meeting WFD goals due to hydromorphological alterations mainly driven by flood defense, river regulations and hydropower. According to the National River Basin Management Plan, river restoration and the reinstatement of lateral and longitudinal continuity are crucial in order to meet the WFD objectives. However, harmonizing measures that improve and maintain ecological status with those measures protecting people against water-related hazards is exceptionally challenging in Austria. To meet this challenge, IRIS is developing and testing an integrated planning tool (the River Development and Risk Management Concept). To enhance both flood protection and the ecological status of Austrian rivers the tool applies a cross-sectoral and interdisciplinary planning approach at the catchment level, while involving various stakeholders and the public. Special attention is given to exploring nature-based solutions for flood protection and securing land for future river development. By defining river corridors where lateral barriers may be removed in the future the tool helps to identify potential free-flowing river stretches. The River Development and Risk Management Concept will be an impactful tool in future Austrian river management as it is to become an integral part of national water policy and a mandatory requirement for public funding of flood protection measures.

D5 Priority actions towards free-flowing Rhine and Maas rivers (Sponsored by Arcadis)

Upstream passage success of large anadromous fish at the Haringvliet estuarine barrier using long-term telemetry monitoring

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Estuaries are important as migration corridors and habitats for diadromous fish species. In many estuaries, connectivity is severely hampered due to human impact, e.g. large dams, tidal barriers, and sluices. These barriers contribute to the decline of migratory fish species, as they cause delays in migration, have low upstream passage success, and increase mortality. In contrast to barriers in rivers, passage behaviour of migrating fish in tidal conditions at estuarine barriers is not much studied. A large estuarine barrier in the Netherlands, the Haringvlietdam, recently implemented adjusted sluice operations ('Kier' management), allowing some inflow of seawater during the high-water period to facilitate upstream fish migration. To assess whether this new sluice regime is successfully increasing fish passage success, it is of importance to determine the situation before the implementation of Kier management. Therefore, in the present study, we evaluated telemetric data of larger anadromous fish species with strong swimming capacity: sea trout, Atlantic salmon and sea lamprey using the NEDAP Trail System® and an extensive network of detection stations in the rivers Meuse and Rhine. During 2001-2018, NEDAP transponders were surgically implanted in ca. 800 fish. Timing of successful passage through the Haringvliet sluices was linked to sluice operations and environmental factors. Passage success tended to be highest at the end of discharging windows, just before sluice closure. Our study provides a knowledge base to improve fish passage at estuarine barriers.

Lessons learned from telemetry: How climate change affects pathways of migratory fish in one of Europe's largest river basins

Niels Brevé

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Historically, the anadromous European sturgeon (Acipenser sturio) and the Atlantic sturgeon (Acipenser oxyrinchus) inhabited most of northwest Europe's marine and large river basins. However, both species became extirpated across their entire former range due to hard river engineering (damming, canalisation), overfishing and environmental pollution. Following a large clean-up effort carried out by the Rhine member states, and in light of evaluating the renewed possibilities for both species' reintroductions, a feasibility assessment has been carried out in the Rhine-Meuse delta, including the Port of Rotterdam and part of the Dutch coastline. The assessment includes the experimental releases of 3–5-year-old individuals (n=87) of the extremely rare A. sturio in 2012 and 2015, tagged for the Nedap Trail system. And in 2023, by further experimental releases of one year old A. sturio juveniles (n=74), tagged for the Vemco acoustic telemetry system. The outcomes highlight several culprits that still hamper the restoration potential of any migratory fish in the Rhine, and other river basin, even if these are (partially) free flowing. Fish migration routes are increasingly impaired by current human-induced climate change. That is, by increased temperatures and droughts during dry summer months: forcing fish and ships in narrowed shipping lanes (increased change of ship propeller strikes) and by a reduced potential to implement fish passage and a permanent brackish water zone at the Rhine-Meuse storm surge barrier system.

A6 River restoration projects

The greatest water management challenges in the Baltic Sea region

Ewa Leś

Coalition Clean Baltic (CCB), Sweden

The CCB analysis "The Greatest Water Management Challenges in the Baltic Sea Region" presents an assessment of the current water management situation in Baltic countries, including also restoration and dam removal/connectivity aspects. The report, research study focuses on the challenges that individual countries face in terms of integrated water management, but also on the common features of the countries surrounding the Baltic Sea influencing inland water management. This analysis aims to support and foster positive changes in integrated water management in the Baltic Sea Region. Our report describes also the status of natural retention, how efficient water management planning is and what action areas are particularly needed. It addresses the essence of restoration of natural retention as a remedy for current water management problems. This activity contributes to the significant target of the EU Biodiversity Strategy (under the European Green Deal) to restore 25,000 km of rivers in Europe to a free-flowing state. This work utilizes the Source-to-Sea approach as well as highlights the impact of inland waters on the Baltic Sea condition.

Rivers of LIFE – Examples of holistic restorations and problem solving in boreal rivers

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Rivers of LIFE is a traditional river-restoration project with the focus on boreal rivers of northern Sweden. The project extends over 6 years and 120 km of rivers, which are in need of restoration and dam-removal due to historical transport of timber for forestry activities. The project involves a great deal of communication and outreach to schools, newly arrived immigrants, landowners and other interested parties, in order to increase the knowledge and awareness of the importance of rivers and why restoration is necessary. The trend now days in river restoration is to focus more on restoring the natural hydrological processes, which in turn creates habitats for plants and animals. If we only restore a riverine habitat without restoring the process that once created the habitat, the restoration likely to fail in the long term or will need continuous managing. Here we present good examples of holistic restorations where the river interacts with the surrounding landscape. In our target rivers we also face stretches where dynamite has been used to remove large boulders and bedrock. Restoring natural hydrological processes where there are large amounts of blasted rock in a small river can be overwhelming even for the most experienced personnel. We discuss the different solutions we have used for restoration under a range of conditions.

Los Angeles river watershed fish passage, restoration, and flows

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Ecological restoration in the Los Angeles (LA) River watershed is proceeding on multiple fronts with the support and engagement of diverse stakeholder groups. Pilot projects to restore habitat, reintroduce native species, and design science-based ecosystem enhancements have produced real benefits to nature and people and demonstrated the potential for additional benefits. The pilot projects, which are in various stages of collaborative planning and implementation, have generated increased interest and financial support to further their implementation and maximize socioecological co-benefits. This self-reinforcing positive feedback is an example of a virtuous cycle established through a combination of long-term environmental planning, community-building, and watershed-scale scientific study to gain the support of stakeholders and align ecological intervention (i.e., restoration) with the plans and policies of governments, resource managers, conservation groups, and grassroots advocacy groups. Conservation and restoration projects targeting iconic and protected focal species can be an effective means of leveraging these interests and building support. The LA River Fish Passage and Habitat Structures project addresses a critical limiting factor for the recovery of endangered steelhead trout (Oncorhynchus mykiss) while also enhancing flow regimes, urban biodiversity, and providing recreational opportunities and other beneficial uses (e.g., ecosystem services) for the surrounding communities. Through these efforts, our planners, ecologists, and engineers are using place-based conservation to demonstrate solutions to problems that affect people and nature in other urban landscapes.

Restoring a lowland river basin: Effects of fishways, removing barriers and re-meandering on fish and invertebrate communities

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Rivers in Europe have been heavily modified to accommodate human needs such as irrigation, flood control, power generation, discharging waste/pollutants and navigation. The catchment of the medium-sized lowland River Dommel (length 120 km; catchment: 1800 km2) in the Netherlands is one such example, with major interventions, like dam and weir construction and regulating watercourses during the 20th century. These modifications have had severe adverse effects on fish and macroinvertebrate communities, especially on the rheophilic species because barriers create impoundments beside hampering dispersal and migration. Within the context of the European Water Framework Directive (WFD), the responsible water authority has been implementing numerous measures to recover fish and macroinvertebrate populations. These measures include improving water quality, constructing fishways, re-meandering river and stream sections to resemble more natural conditions and more recently also removing barriers. In this study we utilized an extensive monitoring dataset from the water authority covering three decades to analyse in detail how barriers, impoundments and the diverse restoration measures affect the distribution and abundance of rheophilic fish and macroinvertebrates. The detailed dataset allowed to perform a catchment-wide Before-After-Control-Impact analysis (BACI) providing valuable insights into the relationships between biota, environmental variables, and restoration measures.

Space for the Oder River – Putting the concept into practice

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The Domaszków-Tarchalice project is an accomplished initiative, the effects of which are now visible on the ground, providing a unique example of the synergy between nature conservation and improved public safety in the Oder Valley region. The initiative, which was created through the cooperation of WWF, local NGO and public authorities as well as the water administration, has brought unique benefits to the local community and the environment. The main objective of the project was to move the dykes, thereby shifting the risk of flooding and preventing disasters similar to the one in 1997. The effects of the project: Firstly, the restoration of the 600-hectare floodplain has succeeded in re-establishing the processes and flooding of the river, which will restore unique ecosystems and restore riparian forests. Thanks to the widening of the embankments and the dismantling of some of the old embankments, the project is now able to intercept as much as 12 million cubic metres of water during floods, resulting in a reduction of the water level over a length of 6.5 kilometres by approximately 0.5 metres. In addition, more than 1,600 hectares of land and 350 residents are now protected from the disastrous effects of flooding.

B6 Ecology and hydromorphology of free-flowing rivers

Weir management and the impact on peak floods and sediment flushing as key factors for the Upper Isar alluvial dynamics

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The Upper Isar is Bavaria's last near-natural wild river. Nevertheless, floodplain dynamics have suffered notable disruptions by the "Krün Weir", a reservoir with a diversion structure established in 1924. Our study delves into the impact of this diversion structure and current management practices, focusing on the challenges and significance of reservoir flushing during peak floods on alluvial habitats and their dynamics. A time series of aerial photos from 1921 to 2018 reveals that nearly a century of weir operation has wrought problematic shifts in alluvial vegetation between the weir and a 12 km stretch downstream, particularly affecting valuable NATURA 2000 habitat types (3220, 3230, and 3240). Notably, sections immediately downstream of the weir have witnessed a 35% reduction in vegetation-free and -poor areas, as opposed to a 23% surge in dense willow scrub. Extensive fieldwork from 2019 to 2021 in 40 transects across the floodplain has shown that large-scale silt deposits, in particular, massively favor the development of the vegetation-poor to dense woody plant stages. The current management of reservoir flushing, in turn, promotes these deposits. In order to ensure the conservation of the NATURA 2000 area, its species, and biotic communities, changes in weir operation are required. This will involve extending reservoir flushing and increasing weir openness during floods.

Greenhouse gas emissions from dammed river basin – A case study at basin scale

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Rivers have always provided fundamental and vital services to people and the environment. Population growth and dependence on freshwater led to the construction of dams. Such dams fragment river ecosystems, creating artificial lentic habitats. Dams also affect fish and other riverine wildlife. In addition to impacts on river structure, dams also affect ecosystem functioning by altering hydrology and sediment dynamics. Although the effects of dams on river ecosystem structure have been extensively studied, their effects on ecosystem functioning remain unclear. Of particular interest is the effect of dams on greenhouse gas (GHG) emissions. Accumulation of sediment and organic matter in lentic areas, as well as anoxic conditions, could promote GHG emissions. Here we present a study analysing GHG emissions at the basin scale. Direct measure of GHG emissions revealed that lentic areas promote GHG production, whereas downstream waterfall and running waters release them. In the context of the Anthropocene, reducing GHG emissions by removing dams and restoring river ecosystems could be one Nature Based Solution to mitigate climate change.

Management of water and forest ecosystems in the Salaca River basin

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Salaca River is the biggest salmon river on the east side of the Baltic Sea. Part of the Salaca River basin is affected by the Staicele Dam. Unfortunately, the Staicele Dam is still located on Salaca, which affects the water quality and fish migration. More than 80% of the banks of Salaca are covered with riparian forest. Since the renewal of the independent Republic of Latvia, agricultural activities within the riparian territories, for several reasons (economic situation, urbanization, and general migration) have been in serious decline. Past grasslands, including protected EU habitats, are overgrown with pioneer species of trees – mainly grey alder. These territories have been transformed from riparian grasslands into riparian forests. Riparian forests are the transition zone between water and terrestrial ecosystems and they provide key functions for retaining and accumulating pollutants and nutrients. The river ecosystem should be evaluated and managed together with the forest ecosystem in the Salaca River basin. Riparian forest management with an ecosystem services approach should be carried out and Staicele Dam should be removed to increase different ecosystem services in the river in the near future. The problems of Salaca have been solved at various levels for more than 30 years, but still, the Staicele Dam from the 19th century crosses Salaca for migrating fish. Local residents and fishermen have been raising problems for the last 5 years, solving them with projects of various scales in the restoration of freshwater habitats (EU biotop 3260*), management of riparian forests, prevention of pollution, etc.

Ontogenetic habitat shifts by juvenile fishes highlight the importance of permanent river-floodplain connectivity and habitat heterogeneity

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Understanding how larval and juvenile fish use habitats in a diverse environment is critical for improving the ecological efficacy of river-floodplain restoration projects. To assess ontogenetic shifts in habitat use of young-of-the-year fishes in the lower Rhine (the Netherlands), we collected and analysed a unique data set of 2,238 sampling events in 18 restored floodplains over three growing seasons (2018-2020). We identified five functional nursery habitats and studied their use from April to September. Both larvae of rheophilic and eurytopic fishes preferred shallow, slow-flowing, sheltered habitats early in their development. Following that, eurytopic fishes relocated to deeper, more sheltered habitats. Some rheophilic species (Chondrostoma nasus and Leuciscus leuciscus) migrated to these deep-water habitats, while others (Leuciscus idus, Romanogobio belingi, and Barbus barbus) preferred to live in the main channel's dynamic, fast-flowing habitats. This habitat shift usually occurs at a length of ca. 50 mm for eurytopic fishes and ca. 100 mm for rheophilic fishes. Species-specific ontogenetic shifts in habitat use were observed within both ecological guilds, emphasising the importance of habitat heterogeneity for a diverse fish community. Based on our results, we propose three floodplain restoration principles to combat declining riverine fish populations and biodiversity in modified large lowland rivers: (1) maintain permanent lateral connectivity between the restored floodplain and the main channel; (2) create high levels of floodplain habitat heterogeneity throughout the growing season of riverine fishes; and (3) build floodplains with deep water habitat that can serve as refuge areas.

The state of European river network connectivity

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Humans greatly modify riverscapes by altering stretches, watersheds, and accelerating climate changes. As a consequence of damming and channelization, longitudinal and lateral connectivity of rivers have been severely compromised, and most rivers are disconnected from their floodplains. The dramatic effects of dams on water, sediment transport and fish movements have made them a common subject of fluvial research. However, most research lacks the distinction between the independent effects of natural pre-existing barriers -waterfalls - and the artificial ones. Most studies have considered the dam as the principal or only barrier impairing longitudinal fish movements. But the upstream water reservoir itself represents a strong ecological barrier because it creates completely different hydrological and limnological conditions. Furthermore, lateral fragmentation is also a significant threat to ecological functions in the river landscape, negatively affecting the development of side-channel habitats, floodplain evolution, riparian ecosystem processes, and biodiversity. Roads and railroads are even more abundant features in riverscapes than dams. Additionally, navigation in heavily developed waterways may impact diversity of fish assemblages, contributing to the effects of migration barriers, pollution, expansion of invasive species, and habitat destruction. To characterize anthropogenic disturbance on longitudinal and lateral connectivity of European rivers, we mapped these ecological barriers, by identifying the river network segments affected by dams and their reservoirs, roads, and railroads, and waterways. Assessing the extent of these disturbances is relevant in the context of attaining goals placed by environmental policies like the Water Framework Directive.

C6 Freshwater fish & fisheries: Restoration of migratory fish populations

Spawning migration of North Sea Houting in the Overijsselse Vecht

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North Sea Houting (Coregonus oxyrinchus) was extinct in the Netherlands. From 1996 to 2006 a reintroduction program was carried out in the River Rhine. Reintroduction was stopped after 2006, when a large part of houtings caught in Lake IJsselmeer turned out to originate from natural reproduction. Since then, the number of houtings observed in the Netherlands has continued to increase. Research with tagged adults and larva revealed that houting probably spawn in the IJssel, a Rhine branch that flows into Lake IJsselmeer. In 2018, during research in the Overijsselse Vecht (Swimway Vecht), more than 150 houtings were unexpectedly caught during their spawning migration. To follow their annual migration, we tagged a total of 61 houtings in 2019 and 2020 with an acoustic transmitter (Innovasea V13, estimated tag life: 1105 days). A telemetry network of 57 hydrophones was installed for project Swimway Vecht, from the upper reaches to Lake Ketelmeer. These hydrophones were located below and above each weir in river and in the largest tributary waters. Several houtings migrated annually towards the Vecht during their spawning period, which occurred in the first half of December. A few houtings were detected at the fish passage of the first weir, but only one houting briefly managed to pass through the fish passage at high discharge. Conclusions are that North Sea houting are homing to spawn in the Overijsselse Vecht and that, despite the presence of a fish passage, the river is still largely inaccessible for the species.

Successful restoration of migratory fish populations confirms the benefits of dam removal in middle-sized rhithral stream

Ričards Kaupužs, Patrīcija Raibarte, Kaspars Abersons

BIOR, Riga, Latvia

Since the 19th century, Aģe River (average discharge: 1.9 m^3/s; basin area: 214.9 km2; average slope: 1.20 m/km) had been dammed by the Teterlīči Mill Dam. After the dismantling of the dam in the late 1980s, additional 7.1 kilometers of river habitat was opened for migratory fish. Fish and lamprey surveys performed within different projects provide insight into a natural recolonization of migratory fish. There are three anadromous fish species found in Aģe River: Atlantic salmon (Salmo salar), brown trout (Salmo trutta) and river lamprey (Lampetra fluviatilis). Data confirms the presence of all three mentioned species in the newly acquired territory. In 2012 salmon parr were captured 6 km upstream from the river mouth, and in 2020 – 10.5 km upstream from the river mouth, indicating ability to recolonize the area at a rate of at least 0.24 km/year, despite the strong homing instinct. In contrast, trout parr were captured 7.4 km upstream from the river mouth as early as 1993, suggesting a recolonization rate of up to 1 km/year for this species. Large abundance of lamprey larvae 4.4 km upstream the former mill dam in 2021 (16.7 specimen/m2) indirectly indicates the presence of anadromous river lamprey. Our data underscore the importance of barrier removal, as it allows for natural recolonization to begin its course.

Mapping sturgeon habitats: A comprehensive overview of sites, protection status and potential threats in selected river systems

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Sturgeons are the most threatened group of species on our planet, with all of the 26 known remaining species at risk of extinction. The primary reason behind this alarming development is their unique protracted life cycle with long migration distances and distinct habitat requirements, which makes sturgeon species particularly vulnerable to human interventions in river ecosystems. Commonly practiced activities such as hydromorphological alterations and poaching cause severe consequences for these flagship species. It is well known that sturgeon species spend the most critical part of their life-cycle in rivers. As the available knowledge about the localization and the characteristics of those habitats is limited, a critical initial step involves the localization of habitats as well as gathering information about their usage. Especially in international river basins such as the Danube or the Rhine, this knowledge can support the indispensable transboundary conservation actions. The objective of this study was to map critical sturgeon habitats in selected river systems and identifying existing knowledge gaps. In a comprehensive data collection with the contribution of regional experts, the habitat locations were identified and characterized regarding their usage. In addition, data concerning existing migration barriers and potentially planned infrastructure projects that could pose a threat to sturgeon habitats was collected. Furthermore, the current habitat protection status was displayed. For this purpose, nature conservation authority data was processed and protected areas were categorized. This research was part of the SCUTE project, supporting the implementation of the Pan European Action Plan for sturgeon.

Downstream spawning migration of European eel (Anguilla anguilla L.): A Europe-wide telemetry meta-analysis

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The European eel (Anguilla anguilla L.) is a critically endangered, facultative catadromous fish species with a wide distribution ranging from northern Africa to northern Europe. The species is considered panmictic and spawns in the Sargasso Sea, an area ca. 5000 km west of the European continent. Since eels need to arrive at the spawning grounds at the same time as their conspecifics, their migration speed and/or timing need to be orchestrated across their distribution. The numerous migration barriers in European waters may potentially delay and even block eels from reaching the sea, hindering the species' population restoration. To gain knowledge on the seaward spawning migration of eels (i.e. the silver eel stage), telemetry has revolutionized our knowledge and understanding of their migration behaviour, often in response to migration barriers. In this study, we combined telemetry data from 18 independent projects in nine countries distributed along the southwest-northeast Atlantic axis from Europe, including the North and Baltic Sea. This resulted in a dataset with a total of 2476 tagged eels which have been tracked between 2002 and early 2021. We observed that the migration speed, timing and escapement success differed according to habitat (i.e. riverine and tidal, such as estuaries and fjords), geographical location and migration barrier types.

Temporal developments of longitudinal connectivity: The perspective of potamodromous fish

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In riverine ecosystems, longitudinal connectivity does not only impact species distribution and hence aquatic biodiversity, but represents a prerequisite for the life-cycle completion of potamodromous fish. However, during the past century, barrier construction in the course of river engineering, energy production and other anthropogenic interferences have resulted in a severe fragmentation of European river networks. Naturally, the resulting connectivity changes have had a major impact on potamodromous fish species. However, the magnitude of this impact is mostly unknown due to interactions with other stressors, missing data and the loss of reference conditions representing the unimpacted state of the concerning river ecosystems. Because the nonlinear process of river fragmentation has been continuing for over a century, estimations of the resulting ecological consequences should also take into account it's temporal aspect. In this talk we present an Austrian case study assessing longitudinal connectivity changes since the beginning of the 20th century from the perspective of potamodromous fish. Our results characterize and quantify this temporal development while identifying periods with high rates of change on the national and local scale. By doing so, we provide valuable information representing one of the building blocks necessary to understand long-term developments of potamodromous fish populations.

D6 Dam Removal – Small barriers

Optimizing restoration resources: Removing multiple dams along urban rivers

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Dams constructed during the early 19th and 20th centuries in the United States were often built in sequence on the same river, typically due to favorable channel conditions and proximity to commerce. No longer serving their initial purpose, many aging dams are being removed due to fish passage and liability concerns. Removing multiple dams in the same river system offers a number of benefits, including potential efficiencies with the design, permitting, and public outreach efforts. There are also challenges with removing structures in sequence such as timing of removals, sediment management, and funding opportunities. This presentation will use examples from a series of dam removals on the Mill River in Taunton, Massachusetts, Red Clay Creek in Wilmington, Delaware, and the Shawsheen River in Andover, Massachusetts to highlight the challenges and opportunities with multiple dam removals in sequence in urban environments.

River connectivity restoration to improve diadromous fish populations: LIFE KANTAURIBAI project

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River fragmentation is the main problem shared by the rivers of the Bay of Biscay. LIFE IREKIBAI project (2015-2020) targeted the improvement of the river connectivity through the removal of 7 dams and other habitat restoration actions in two rivers shared by two regions. Now, its successor LIFE KANTAURIBAI (2022-2027) goes one step further in ambition, extending the project area to 5 river catchments shared among 3 regions of 2 countries (Spain & France): Oria and Urumea (shared by Navarra & Gipuzkoa), La Nive & La Nivelle (shared by Navarra & Aquitaine) and Bidasoa (shared by the 3 regions). The project aims to restore the river connectivity and reduce fish mortality, to improve the conservation status of species linked to the fluvial ecosystem in 15 Natura 2000 sites. Target species include diadromous fish (Salmon, Lamprey, Shad and Eel), Margaritifera, Pyrenean Desman, European Mink and the main target habitat is the Alluvial forests of Alder and Ash (91E0*). The project foresees removing 25 dams and constructing 7 fish passes to improve river connectivity. It will also quantify the fish mortality on the downstream migration in the HPPs (dates, flows, etc.) and propose corrective measures designed ad-hoc in five HPPs, with the aim that these are replicable in other plants beyond the framework of the project. Other expected results include the installation of automated control and monitoring systems for migratory fish, 91E0 habitat restoration, creation of the Bidasoa Migratory Fish working group to allow international coordination in the management and monitoring of migratory fish species.

First steps in restoring longitudinal connectivity on Vâlsan River - home of critically endangered fish species Asprete

Mircea Marginean, Iain Trewby

Fauna & Flora, Deva, Romania

Globally, freshwater ecosystems represent some of the most degraded habitats, with Europe's watersheds being heavily degraded. Since 2011, Fauna & Flora (FF) alongside partners have worked to address threats to Romania's wildlife, habitats and biodiversity. Conservation of Europe's most endangered freshwater fish – Asprete, critically endangered, offers an opportunity to tackle the conservation of a flagship species within critical freshwater ecosystems. One of the major threats to this unique species – the rarest freshwater fish species in Europe is Vâlsan River fragmentation caused by 4 weirs. Scientific fishing surveys carried out in 2022 and 2023 by Alex Găvan Foundation (AGF) together with FF discovered the presence of a population of Asprete isolated between two weirs. Through the OR program, FF works alongside its partner AGF to carry out the preparatory activities in order to find solutions and best methods to remove these obstacles. One of the biggest challenges in achieving the removal of these obstacles is a sewer pipe which crosses two of the weirs. This presents a huge ecological risk of breaking and contaminating the entire aquatic ecosystem, being exposed, no longer protected by the concrete of the weir, which has eroded over time. Detailed feasibility study, including Environmental Impact Assessments, supported by biotic and abiotic studies are carried out to find the possibility of removing and the impact to the ecosystems and species caused by removing the weirs. Technical DR plans will be drawn up by engineers in consultation with authorities, providing clear methods for removing each weir.

Galaxes weir removal: An ORP-funded project kickstarting the civic movement for the restoration of river connectivity in Portugal

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Dam Removal in Portugal has been almost null until recently. In 2021, some removals were finally initiated by public authorities, and more recently strengthened with civil-society-led removals. In March 2023, ANP|WWF removed an obsolete weir on the Odeleite River, at the Galaxes locality (Algarve, Southern Portugal). This was the first ever removal made by an NGO in Portugal. The following month, another weir was removed by another environmental NGO, and other removals are in the pipeline, finally boosting the Dam Removal Movement in the country. The Galaxes weir removal restored 7.7 km of river connectivity, improving habitat for relevant biodiversity, including the Saramugo (the most threatened non-migratory freshwater fish species in Portugal, endemic of the Guadiana basin), the eel, the otter and the endemic and Endangered Iberian lynx. Besides the removal, ANP|WWF i) publicly presented the project and its benefits to the local community, ii) performed an environmental education session in a local school, iii) co-hosted the 7th edition of the Dam Removal Europe International Seminar, iv) held several meetings with relevant stakeholders, v) collected fish and sediments samples, and vi) developed communication and awareness raising tools to scale up dam removal in Portugal. All activities have been financed by the European Open Rivers Programme grant and co-funding. The final step will be the planting of autochthonous trees and shrubs to restore the riparian vegetation. The main challenges faced with starting the dam removal movement in Portugal and lessons learnt during the Galaxes removal will also be shared.

Removing redundant gauging weirs to benefit migratory fish in Wales

Melissa Mahavar-Snow

Natural Resources Wales, Cardiff, United Kingdom

In 2023, Natural Resources Wales removed two redundant river gauging weirs that posed significant barriers to fish movement. This talk presents the projects from conception to post-construction, including lessons learnt for future schemes. The first project, on the River Honddu near Brecon opened up 20 km of habitat to migratory fish. Working in a well-used steep sided public woodland and the River Usk SAC, it required close collaboration with the local council and the public. Access down to the weir was a real challenge. Ash-dieback felled timber was used to stabilise the bed and banks in the restored river reach. The second project, on the River Clywedog near Llanidloes opened up 4 km of habitat to migratory fish. Removal was extremely challenging as the window of opportunity was very limited due to natural rainfall, reservoir regulation water releases, reservoir flood drawdowns, availability of a spider excavator plus the works needed to be completed during the closed season of an adjacent caravan park. Success comes instantly once the barrier is removed - fish passage has been made easier. Both sites have had a makeover – out with the ugly concrete and in with the beautiful free flowing rivers and restoration of natural processes. We will continue to monitor the long-term impacts to fish populations. These barriers might be small compared with those in other countries but in Wales we are passionate about doing all we can to improve the environment for migratory fish.

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