THE VJOSA RIVER

A BASELINE SURVEY

on biodiversity, potential impacts, and legal framework for hydropower development

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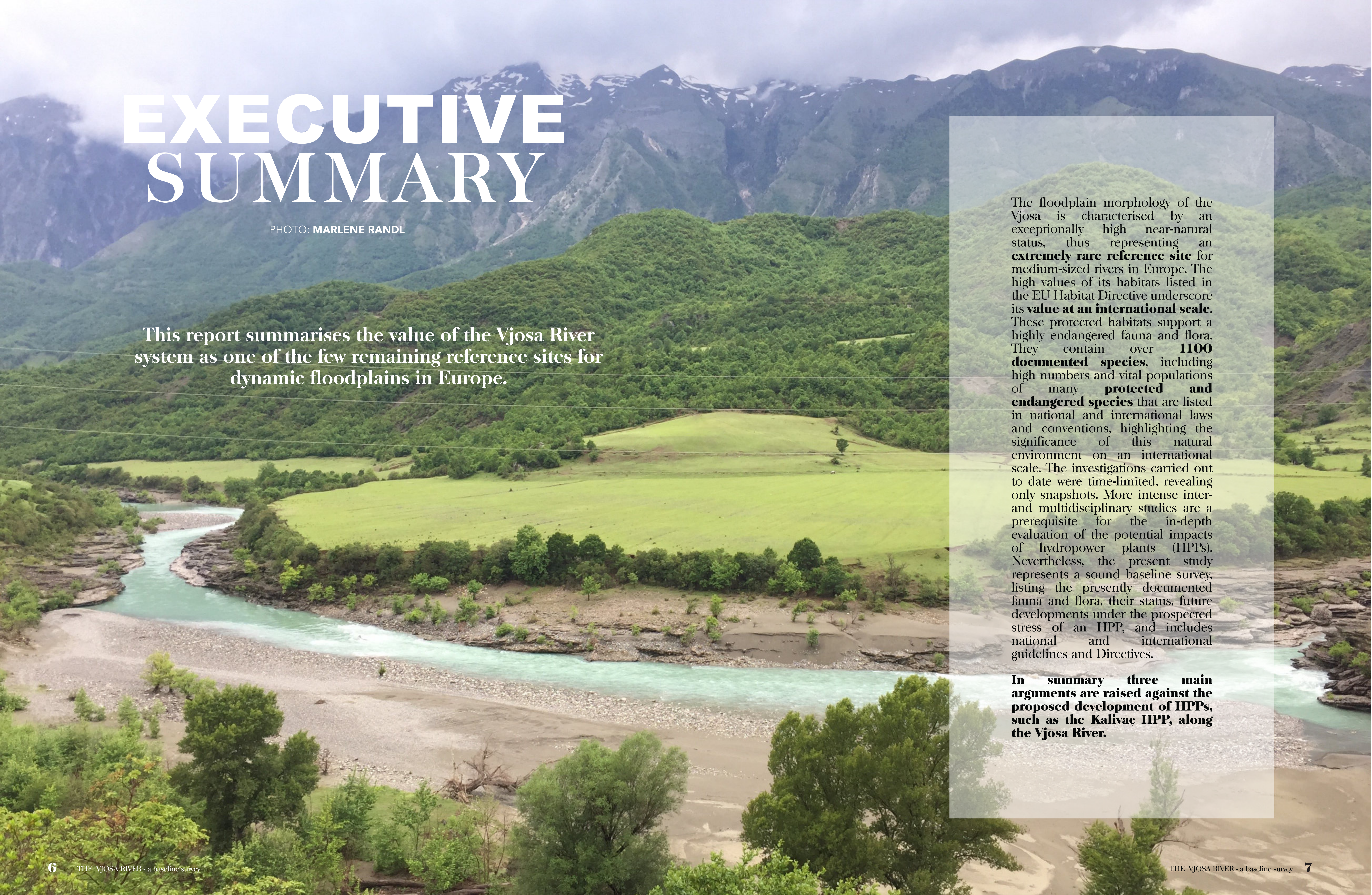

EXECUTIVE SUMMARY

PHOTO: **MARLENE RANDL**

This report summarises the value of the Vjosa River system as one of the few remaining reference sites for dynamic floodplains in Europe.

The floodplain morphology of the Vjosa is characterised by an exceptionally high near-natural status, thus representing an **extremely rare reference site** for medium-sized rivers in Europe. The high values of its habitats listed in the EU Habitat Directive underscore its **value at an international scale**. These protected habitats support a highly endangered fauna and flora. They contain over **1100 documented species**, including high numbers and vital populations of many **protected and endangered species** that are listed in national and international laws and conventions, highlighting the significance of this natural environment on an international scale. The investigations carried out to date were time-limited, revealing only snapshots. More intense inter- and multidisciplinary studies are a prerequisite for the in-depth evaluation of the potential impacts of hydropower plants (HPPs). Nevertheless, the present study represents a sound baseline survey, listing the presently documented fauna and flora, their status, future developments under the prospected stress of an HPP, and includes national and international guidelines and Directives.

In summary three main arguments are raised against the proposed development of HPPs, such as the Kalivaç HPP, along the Vjosa River.

Argument 1

Ecological degradation of a large, unique river system and consequent biodiversity losses

PHOTO: **DAN MEYERS ON UNSPLASH**

The planned Kalivaç HPP would lead to the complete and irretrievable loss of more than 1000 ha of natural and near-natural river and floodplain landscape owing to damming. The drastically reduced hydromorphodynamics and resultant bed-load deficit would cause large areas of typical riparian habitat to be lost downstream of the dam. These effects cannot be compensated for by mitigation measures and would lead to the **destruction of one of the greatest wild river landscapes in Europe**. The reservoir (18.3 km²) stands out as the area that would be most severely affected with a total **local decrease of around 40% of all species**. However, the river reaches both downstream and upstream (including tributaries) would also be markedly impacted by the HPP. The major impact upstream would be the complete blockage of aquatic migratory fish species, such as the critically endangered European eel. After construction of the proposed dam at Kalivaç, **881 km of the 1109 km of permanent river network length would no longer be reachable by migratory fish**. Although often ignored, the downstream effects of HPPs pose equal or even greater threats to aquatic and semiaquatic species than the upstream effects. In the present case, approx. 110 km would be affected, mainly by changes in the discharge and sediment regimes, reaching downstream to the Adriatic Sea and the delta region. Long-term effects, especially, have the **potential to change fauna and flora composition entirely and irreversible**.

ARGUMENT 2

Violation of signed laws and conventions

The study demonstrates a high risk of local extinction in the study area owing to the planned HPP, which is not limited to only the immediate project area, but also includes the downstream sections of the river and the Vjosa-Narta Delta. Provided that Albania does not cancel their integration process into the European Union, it must approximate its national legislation and assessment procedures with the legislation/regulations of the European Union. In summary, **870 ha of habitat on the EU Habitat Directive will be directly lost** in the area of the HPP reservoir. Furthermore, at least **2800 ha** habitat on the Habitat Directive will be **directly affected** downstream of the dam by reduced morphodynamics, and the long-term loss of protected habitats can be expected. Thirty-nine species are listed by the **IUCN** and 119 on the **Albanian Red List**, whereas 15 and 74, respectively, are listed in threatened categories. A total of 148 species are listed in Annex 1–3 of the **Bern Convention**, 41 in the **Birds Directive** and 78 in the **Habitat Directive**. An evaluation based on expert judgement revealed that many of the species listed in these Directives and Conventions would be severely impacted by the HPP, ranging from small-scale reduction to local extinction, or even complete fallout. In addition, more Directives, like the **European Eel Directive**, need to be considered. As many internationally protected species would be affected, which the Albanian government has a responsibility to protect owing to their signing of various international and national agreements, it must be ensured that additional populations of the affected species occur in Albania and its neighbouring countries, to prevent national or wider extinction. Another example is the **Espoo Convention** that requires the state in which a project is planned to investigate and assess the environmental impacts of the project on neighbouring states, if the project is likely to have a significant adverse transboundary environmental impact. The severe impacts predicted in this report, with lasting and irreparable losses, will under no circumstances allow a positive assessment of the Kalivaç (and/or Poçem) Project. The grant of a derogation would require imperative reasons for overriding public interest and the absence of alternative solutions.

ARGUMENT 3

High economic costs owing to sediment-related problems

PHOTO: **GEROLD HINZEN ON UNSPLASH**

Detailed sediment-budget calculations showed that the **Vjosa reservoirs** would be filled with sediment within 30–40 years in Poçem and 45–60 years in Kalivaç. The Kalivaç reservoir would consistently be filled with sediment, leading to a **2% loss of energy potential each year**. After 20 years, the HPP would lack 40% of its original capacity. To overcome these issues, **dredging would be necessary** from the first year of operation. Owing to the lack of sediment downstream of the dam, the Vjosa **riverbed would erode progressively deeper** into the ground, also lowering the **ground water level**. **Coastal (lagoon) erosion** would increase owing to a lack of sediment transport. Ecological degradation and a **loss of European sea-side tourism**, as well as eco-tourism in the Vjosa catchment, would follow. Therefore, it can be concluded that the construction of dams & reservoirs in this specific river, and particularly in this section of the river system (with its large catchment areas and high sediment loads), is risky in terms of energy generation and profitability.

The planned project clearly contradicts the concept of sustainable development, also from an economic perspective.

The project would significantly degrade the extremely high ecologic value of the entire Vjosa River from the delta to the areas upstream of the planned dam.

Violations of international and national law can be clearly identified within the planned project.

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INTRODUCTION

PHOTO: **ANTOINE SIMILON ON UNSPLASH**

This report provides a baseline survey on biodiversity, focusing on (aquatic) organisms of international interest, like fish and macroinvertebrates, but also assessing terrestrial vegetation. Chapter "General Impacts of Hydropower Plants" describes the potential impacts of HPPs on biota, and chapter "Legal Framework and Evaluation/Assessment Criteria" the legal framework of international Directives and Guidelines. The study further illustrates the predicted effects of the Kalivaç HPP on the documented organisms and habitats of the river system.

A perquisite and the basis of an Environmental Impact Assessment (EIA) is a description of the current state of relevant aspects of the environment (baseline survey) and an outline of their likely evolution in the event of project implementation. These natural changes from the baseline scenario should be assessed as accurately as possible with reasonable effort, depending on the availability of environmental information and scientific knowledge. The aim of this report is to provide a **scientific framework**, a baseline for a valid EIA, and support material for demonstrating the potential violations of international laws and agreements by the construction of hydropower dams along the Vjosa River in Albania.

CHARACTERISTICS OF VJOSA

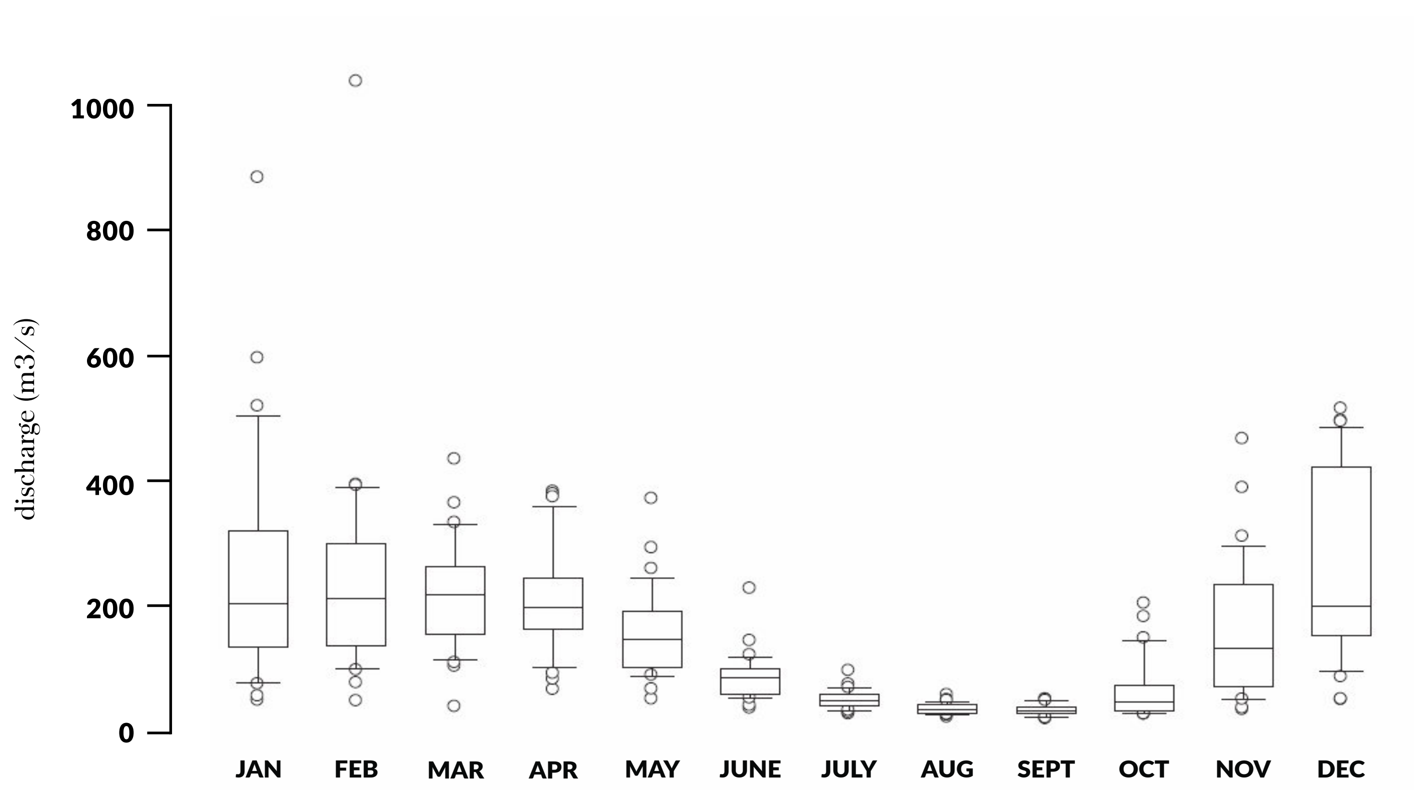
Overall, the Vjosa is 270 km long,
with a total catchment area of
6710 km2 and a total stream
network length of approx.

1100 km of permanently flowing river.

Figure 1. Catchment of the Vjosa/Aoos River and its main tributaries.

The Vjosa River has its source in the Pindus Mountains in Epirus, Greece, passes the Greek-Albanian border, and then flows northwest (Figure 1).

Along the right bank, the Sarandoporos (Albanian: Sarandoporo) and Lengarica (Albanian: Lengaricë) tributaries run into the main stream. Along the left bank are the Drino (Albanian: Drin), Bënça (Albanian: Bënçë), and Shushica (Albanian: Shushicë) affluents. In the lower course, between the cities of Fier (Albanian: Fieri) and Vlora (Albanian: Vlorë), the Vjosa crosses the lowlands of Myzeqeja (Albanian: Myzeqe). The river expands in this section and forms wide, outbound meanders. The river delta is located north of Natra Lagoon.



The geomorphology of the Vjosa basin is characterised by the NW−SE orientation of the folded structures and tectonic planes. Along its course, various channel types occur, with gorges in the upper parts, braiding and anabranching in the middle and lower courses, and meandering close to the river mouth.
The hydrology of the Vjosa catchment is classified as pluvio-nival and reflects a typical Mediterranean climate in the downstream sections and an alpine climate in the rhithral sections in Greece. Discharge extremes therefore occur in late summer−autumn, and in late winter−early spring (Figure 2). Daily discharge is highly unpredictable. The annual mean flow at Poçem is 141.5 m3 s−1 and the recorded maximum 3140 m3 s−1 (1963) (Schiemer et al. 2020).

Figure 2. Boxplot of the monthly average discharge of the Vjosa in the Dorez region from 1958–1990 (Hauer et al., 2019).

The relevance of fluvial dynamics for Habitat turnover and biodiversity

Ward et al. (1999) postulated that physical disturbances are key players in the biodiversity and ecological functions of riverine ecosystems. Since the Vjosa shows an almost unimpaired hydromorphology, its geomorphic dynamics remain minimally affected. Within the framework of Nanson and Knighton (1996) the Vjosa River is classified as a laterally active gravel-bed river.

The Vjosa catchment offers a high annual sediment yield of 20−40 t ha−1 (Hauer et al. 2019). Because of this, the bed load supply is greater than its channel transport capacity, leading to anabranching and braiding river types. A reduction of sediment supply would therefore lead to a more stable, sinuous channel, completely transforming the river and floodplain (Carson 1984). Avulsion also plays a vital role in the concatenation of the river with the active floodplain. Up to 3 m high, avulsions demonstrate the positive interactions resulting from the geomorphic continuum.

The research of Schiemer et al. (2018) further analysed the displacement of sediment and habitat turnover. They illustrate the total turnover of the river−floodplain system in less than 100 years with a 20% change of river position per year. Small islands with pioneer vegetation and shrubs have a turnover rate of approx. 5−10 years, whereas isolated erosion pools have the shortest turnover rate, of less than a year, owing to erosion and sedimentation. The Vjosa River is therefore a prime example of the dynamic equilibrium of habitats in a ‘constantly shifting mosaic steady state’ (Bormann and Likens 1979).

A ‘natural flood regime’ (Poff et al. 1997) associated with a ‘natural sediment regime’ (Wohl et al. 2015) generates high spatio-temporal heterogeneity, continuous habitat rejuvenation, and biotic succession. The wide range of habitat types and ecotones, combined with dynamic water level fluctuations, provide conditions suitable for the specific associations of well-adapted species (Schiemer et al. 2020).

The Balkan region has the initial advantage of being a hotspot of biodiversity (Krystufek and Reed 2004). Combining this with the highly dynamic system and fast habitat turnover of an active gravel-bed river (a heterogeneous structure with transition zones) only enhances the available ecotones. Consequently, the possible number of specialists that can inhabit these areas is also enhanced. In addition to the spatial changes, the temporal changes created by floods initiate high levels of alpha, beta, and gamma diversity (Ward et al. 1999). Ultimately, this fluvial dynamism, and the resulting high biodiversity, is based on an uninterrupted longitudinal continuum (Schiemer et al. 2020; Schiemer et al. 2018).

Aquatic and (semi)terrestrial habitats

The uninterrupted longitudinal and lateral expansion of the river enables manifold aquatic and semi-terrestrial habitats to be created. The following classification provides an overview of the potential habitat types, supporting a variety of different floral and faunal communities.

Larger islands and gravel bars within the active channel are strongly structured by erosion channels and show the cumulative effects of changing water levels and flow pulses. Within the active channel, large bars are deposited, and more perennial islands are formed, characteristic of braided river sections. The river segments under consideration are partially constrained by bedrock structures, leading to a high variability in the lateral extent of the riverine landscape. Gorges constitute bottlenecks in sediment transport, resulting in not only lateral, but also longitudinal sorting processes.

Besides the high gravel load, a large amount of finer sediment is transported by the river - a significant feature that creates large silt deposit areas but also causes high compaction and reduces the porosity of the riverbed. The floodplain is characterised by its extraordinary dynamism and the frequent relocation of the active channel, partially owing to channel avulsion (Schiemer et al. 2020). The resulting diversity of aquatic and terrestrial habitat types are described in (Meulenbroek et al. 2018a; Schiemer et al. 2018) and (Schiemer et al. 2020). A selection of these habitats is illustrated in Figure 3. The wide range of habitat types and ecotones, in combination with dynamic water level fluctuations, provide the necessary conditions for the specific associations of well-adapted species (Schiemer et al. 2020).

Figure 3. Overview of selected aquatic (brown boxes) and (semi)terrestrial (white boxes) habitats along the lateral expansion of the Vjosa River. Numbers in brackets indicate Habitat-Directive types (see chapter Baseline survey of Fauna and Flora).

R

Reference for Europe

The pristine or nearly pristine conditions of this watershed allow the possible creation of a myriad of different ecosystems, like narrow gorges, wide braided river sections, and a near-natural delta, with huge variation in their areal and temporal dynamics. Minimal anthropogenic impact has preserved a living river network which is internationally outstanding (Schiemer et al. 2020). Only small-scale interruptions along two tributaries exist, enabling a mostly unimpeded dynamic flow along its longitudinal, vertical, and lateral dimensions. This minimally impaired morphology and ecology is extremely rare in Europe. Internationally, intensive management of river landscapes has taken its toll on the overall diversity, heterogeneity, and ecosystem services that a typical medium to large-scale river can provide. Since large-scale river regulation was already occurring in the mid-19th century, covering large parts of Europe, finding an ecosystem without major anthropogenic influence, or referable data to assess a river's ecological status or potential, is difficult (Antonelli et al. 2004; Tockner and Stanford 2002).

The European Union defines reference conditions as systems before the influence of intensive agriculture, forestry, and industrial disturbances (Commission of the European Communities 2000). The data from this period (prior to the 19th century) can only create a loose general framework of how living conditions in medium to large-scale rivers were, previous to any morphological or land use alterations (Hughes et al. 1986). One approach to combat this problem is by attempting to fill in the missing data through the use of extant data, modelling, and expert judgement (Whittier et al. 2007).

Not only do morphological alterations change feeding guild composition and habitat availability, but systematic land use change and the cultivation of surrounding floodplains changes the runoff and therefore the hydrology and sediment input of rivers. The consequences can be extensive and a real picture of the habitat and feeding conditions prior to human settlement impossible to obtain. At the Vjosa River, we have the unique possibility of gaining this missing data on the reference conditions of large, natural rivers. The recently published study by Schiemer et al. (2020) underscores the value of the Vjosa as one of the few remaining reference sites for dynamic floodplains in Europe and as a natural laboratory for interdisciplinary research.

Hydropower development in the Vjosa catchment

Although the Vjosa is still mainly unimpaired, it is seriously threatened. In the next few years, about 3000 hydropower dams are planned in the Balkans, while about 1000 are already under operation. About 37% (1004) of the planned projects are to be constructed in nature protection areas (see the Eco-Masterplan for Balkan rivers (2018)).

Figure 4 indicates the dimension of these construction works. Within the next few years every large tributary and the main river of the Albanian Vjosa watershed is scheduled to be damned, interrupted, or hydromorphologically altered. The river has recently come under threat from two already-commissioned hydropower dams in its lower reaches. While it is evident that the construction of these HPPs would have a severe impact on the conservation value of the Vjosa, the decision to construct these dams has been made without any comprehensive assessment of the possible environmental and socioeconomic effects and without considering possible alternatives.

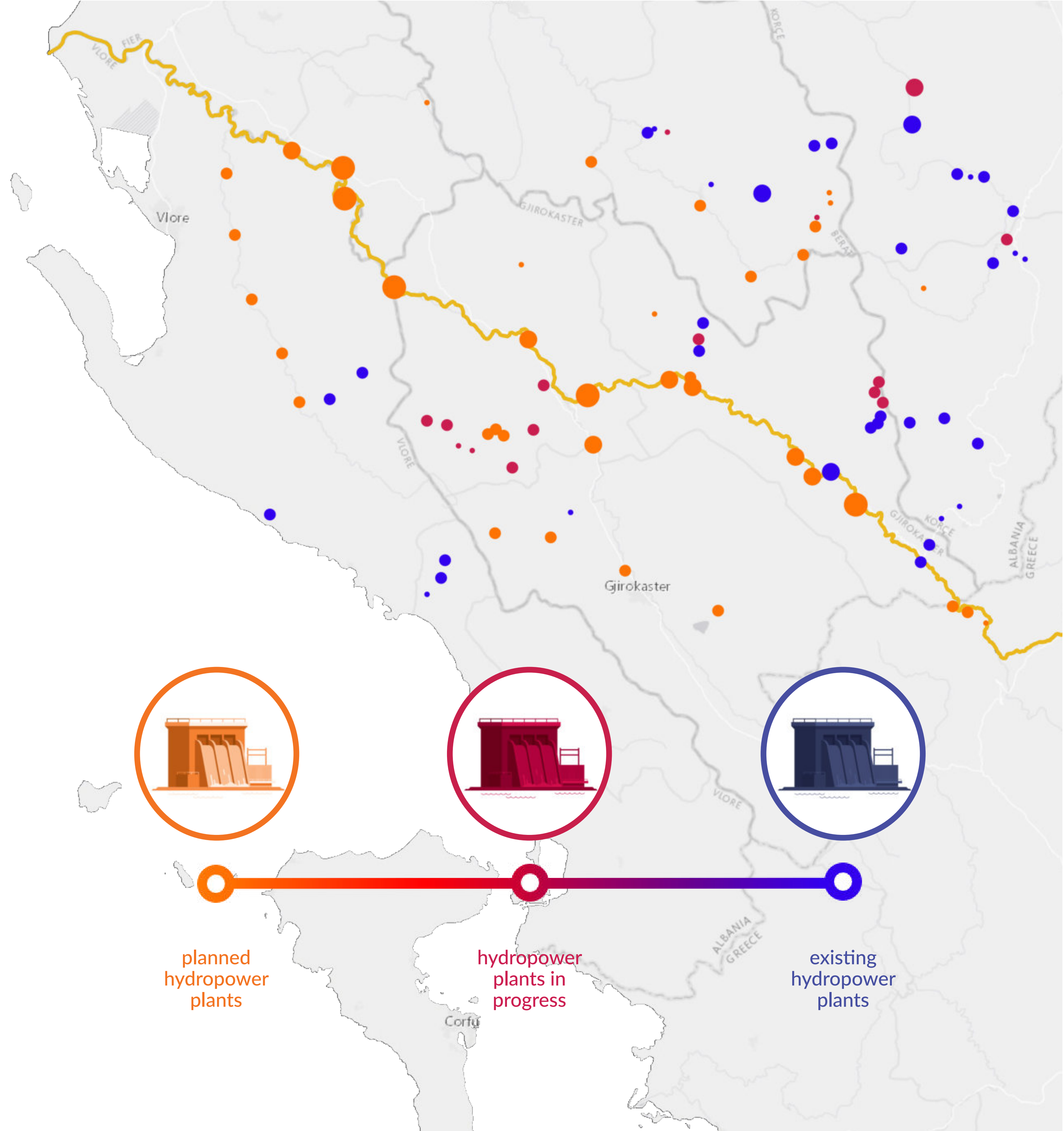


Figure 4. Dam projects on the Vjosa River and its tributaries, and their status modified after Riverwatch (https://riverwatch.eu/en/balkanrivers/map, 2020).

Esri, HERE, Gamin, (c) OpenStreetMap contributors, and the GIS user community

GENERAL IMPACTS OF HYDROPOWER PLANTS

PHOTO: **KEES STREEFKERK ON UNSPLASH**

In general, the term 'hydropower plant' refers to facilities that use the kinetic energy of water to produce electricity. This chapter will summarise and explain the major negative effects of such facilities on aquatic and semiaquatic species, although the problems they cause are far more extensive.

For example, HPPs can disrupt nutrient cycles, produce greenhouse gas emissions, and even increase the probabilities of landslides and earthquakes (Rudd et al. 1993; Tuan et al. 2017; Van Cappellen and Maavara 2016). Braided rivers are dominated by hydrological disturbance and seasonal and interannual streamflow variability which are inherent and essential characteristics, determining physical heterogeneity, and thus the diversity of biota, in time and space. Dams have a huge and severe influence on several aspects of riverine ecosystems. They disrupt inherent processes, like energy flow, nutrient cycling (Ru et al. 2020), sediment balancing, and connectivity (Gilvear et al. 2016; Poff and Hart 2002; Wohl 2019), and reduce hydrological dynamics (Graf 2006). This leads to serial discontinuity which severely impacts all sections of the river, not only the reservoir area (Schmutz and Moog 2018). Numerous studies reveal large-scale trends of fish species loss and reduced abundance owing to habitat loss, habitat fragmentation, and the disruption of the hydrological regime (E.g. Carvajal-Quintero et al. 2017; Dynesius and Nilsson 1994; Liermann et al. 2012; Nilsson et al. 2005).

Upstream effects

The major impact that HPPs have on upstream river communities is that of continuum disruption. Migratory species are blocked from reaching their spawning habitats, genetic exchange is prevented, and the creation of genetic 'island populations' is supported. The genetic impoverishment caused by this isolation decreases the health of the entire population by reducing the possibility of better adaption through the random genetic mutation of individuals (Schmutz and Sendzimir 2018).

The upstream reaches of the river are affected by the dam itself as a migration barrier. It essentially impoverishes migratory species, including catadromous and anadromous fish species like eels, among others. This habitat fragmentation leads to an impoverished aquatic fauna, including aquatic invertebrates, owing to the isolation of populations and reduced genetic exchange (Monaghan et al. 2002; Zwick 1992).

Reservoir

The reservoir is a completely new ecosystem. It is not comparable with the river itself as flow is the decisive parameter, responsible for oxygen content and sediment distribution among other factors. Within the reservoir, the temperature and discharge regime are completely altered. Fine sedimentation negatively affects most riverine biota, especially macroinvertebrates, leading to a complete turnover of the community and reducing the biodiversity to just a few lacustrine taxa. Biodiversity can be high in littoral habitats, but they suffer regular disturbance, such as artificial water level fluctuations, drawdowns, and floods. By exceeding subtle thresholds, these fluctuations can result in littoral dead zones (Schmutz and Moog 2018). The large-scale destruction of the semiterrestrial bank and floodplain habitats owing to damming is particularly relevant in the case of the planned Vjosa HPP, where the entire valley floor will be flooded.

Because of the stagnant waters within the reservoir and the enhanced sedimentation of organic material, eutrophication is a frequent phenomenon. In contrast to running water, self-purification processes are strongly reduced, and the water quality therefore deteriorates quickly, especially at the bottom where there is little dissolved oxygen. The water in reservoirs is therefore frequently classified as poor or bad quality (Commission of the European Communities 2000; Ofenböck et al. 2011).

The implementation of HPPs in rivers and the associated creation of reservoirs can lead to an alternate state or a total shift in ecosystem, because dams alter the flow regime, a major influence in rivers, and influence the hydromorphology, nutrient cycles, and species distribution of the river (Baxter 1977; Poff et al. 1997). Species that show migratory or rheophilic traits, and/or are dependent on habitats formed by fluvial processes, suffer heavy losses.

Damming in rivers leads to increased water temperatures in the impounded sections, which might lead to colonisation by species adapted to warmer temperatures. This called potamalisation, or a shift from rhithral to potamal communities (Jungwirth et al. 2003). The highest biodiversity in reservoirs can be found in littoral environments (the shoreline), because of their better and more diverse feeding opportunities, shelter, and habitat. However, owing to the general water level fluctuations in reservoirs littoral fauna and flora might be exposed to more physical stress (Agostinho et al. 2008). The reduced flow patterns in reservoirs lead to increased sedimentation and the clogging of interstitial spaces. Moreover, the filling up of the reservoir leads to decreased water storage, and thus to decreased potential energy storage (see Chapter "Sediment transport and morphodynamics").

Downstream effects

Sections downstream of the reservoir are seriously affected as hydrological dynamics are dampened considerably during HPP operation. In combination with sediment trapping by the reservoir, this leads to the incision of the riverbed, changing the geomorphological characteristics and habitat availability completely. As delta areas are dependent on substrate input from upstream, the hampered sediment supply can change these areas considerably. Nutrient cycling and food web alterations within the reservoir, combined with changes in water temperature, influence the composition of the whole community downstream of the outlet. Although frequently ignored, the downstream effects of HPPs pose equal or even greater threats to aquatic and semiaquatic species than their upstream effects.

Dams heavily modify the natural flow regime of the river downstream. They adversely affect floodplain ecosystems because they are dependent on fluctuations in discharge and especially on extreme events (floods and droughts). HPPs produce homogenous discharges, decreasing floods and overcoming dry periods (Junk 1997).

These flow alterations also have a significant influence on downstream communities. Less lateral connectivity between the river and the riparian vegetation leads to hydromorphological alterations. Owing to the lack of sediment and reduced hydromorphodynamic effects, the progression of the vegetation increases and the riverbed becomes overgrown with vegetation. Particularly, the proportion of young succession phase habitats, like gravel bars, pioneer vegetation, and pioneer-shrub vegetation, will diminish in the short- to mid-term. The loss of spawning, nursing, and juvenile habitats leads to higher mortality amongst young fish (Agostinho et al. 2008). In addition to the blockage of the up- and downstream migration of fish, the altered flow patterns can increase downstream drift and cause the stranding of young fish and macroinvertebrates (Zhong and Power 1996).

The interruption of the sediment regime and the retention of sediment upstream leads to a depletion of sediment downstream of the barrier. Some negative effects of a reduced sediment load in a river are channel incision through the erosion of bed-material and habitat loss for shoreline species owing to the erosion of fine material and the large grain sizes of the remaining substrate (Kondolf 1997). Riverbed incision weakens lateral connectivity. Combined with reduced flow-fluctuation, floodplain habitats face reduction and fragmentation (Schmutz and Sendzimir 2018).

As delta areas are dependent on substrate input from upstream, the hampered sediment supply can change these areas considerably. Nutrient cycling, food web, and water temperature changes within the reservoir influence the composition of the whole community downstream of the outlet (see Chapter "Sediment transport and morphodynamics"). Additionally, changes in thermal regimes owing to hypolimnetic or surface water releases can extirpate stenothermal species (Edwards 1978; Vanicek 1970).

Sediment accumulation in the reservoir results in the need to flush intake basins periodically, which leads to increased turbidity and the clogging of the river bottom downstream with fine sediment. This can lead to a breakdown of fish populations and especially affects interstitial-dwelling macroinvertebrates like *Xanthoperla apicalis* (Gabbud et al. 2019).

HPP operations lead to variable and short-term changes in hydrology, according to power demand. This so-called hydropeaking frequently causes the drift (owing to increased hydraulic forces) and stranding (owing to the reduction of the wetted area) of fish and macroinvertebrates, considerably reducing biodiversity and biomass in the downstream sections of the river (Greimel et al. 2018; Schülting et al. 2016).

During construction

The filling of the reservoir leads to highly reduced (if any) flow downstream. This has severe implications for the organisms living there. The residual flow leads to higher water temperatures, algal growth, and reduced water quality, and to the siltation of interstitial habitats, considerably reducing the overall abundance of oxygen-dependent organisms and of certain functional feeding types, such as grazers. The duration and seasonality of the residual flow is decisive in determining which organisms will survive and to what extent.

The reduction of the wetted area owing to residual flow is correlated with the loss of biomass downstream. The drying of the river bottom can lead to the extinction of aquatic species. The vital question here is where and how far away the nearest populations live and whether repopulation is possible. Plausible and detailed answers must be provided by the operator of the HPP within an EIA. Mitigation, such as the exact minimum residual flow considering the remaining wetted area and flow dynamics, must be implemented to prevent downstream organisms from local extinction.

Summary

The damming of rivers crucially alters the natural dynamics of ecologically important flows on continental to global scales, and in many areas of the world, the anthropogenic modification of catchments and rivers has drastically altered them (Nilsson et al. 2005; Tockner and Stanford 2002; Ward and Stanford 1995). The modification effects of dams are largely well understood, and are of critical conservation importance (Poff et al. 2007).

To summarise, 'dams arguably have a continental-scale effect of homogenising regionally distinct environmental templates, thereby creating conditions that favour the spread of cosmopolitan, non indigenous species at the expense of locally adapted native biota' (Poff et al. 2007). This means that the damming of rivers in general, and specifically of braided rivers like the Vjosa, threatens native biodiversity and ecosystem functioning, as well as the linked ecosystem services on which local people depend. The impacts of damming the Vjosa River would not be locally restricted but would comprise the whole Vjosa, as they would interrupt the reproductive cycles and productivity of various fish species along the whole river. The downstream geomorphological and ecological effects would reach as far as the delta owing to the interruption of sediment supply, altering the habitat-composition there considerably.

KALIVAÇ DAM PROJECT

The Kalivaç HPP project started in 1997 and was the first HPP project on the Vjosa, entering the implementation process in 2007. The planned head of the Kalivaç HPP is 37 m, between 110 m and 73 m above sea level. A 43-m-high concrete-faced rockfill dam is planned, with a reservoir surface area of 16 km2, a live storage volume of about 205 million m^3, and a dead storage volume of about 170 million m^3.

PHOTO: **RIVERWATCH/EICHELMANN**

The turbines consist of two Kaplan units and one Francis unit and will have a capacity of 111 MW. The HPP is planned for daily peaking operation, influenced by power price. Inflows are planned to achieve the highest power sale prices and for seasonal regulation. No information on the exact operational mode (e.g., the amplitude and frequency of pulse-release or the residual flow during reservoir filling and operation), mitigation measures (either constructional, such as fish bypasses, or operational measures), or alternative solutions is available (ABKONS 2019a, b). According to the results of 2D depth-averaged hydrodynamic-numerical modelling, the construction of the projected dam at Kalivaç would create an impounded area of 1.83 million m^2, with a length of 14.5 km (linear distance). The head of the reservoir would be about 800 m downstream of the bridge of Memaliaj. A total storage volume of 309 million m^3 was calculated. The highest modelled depth-averaged flow velocity within the reservoir showed a narrow stream 3.4 km away from the head of the reservoir with a flow of 0.47 m/s. Within a 2.9-km-long section upstream of the dam, which has a narrow valley shape, the modelled velocities reached 0.2 m s–1. Nevertheless, most of the impounded area shows depth-averaged flow velocities close to zero (Hauer et al. 2019) (see Chapter “Sediment transport and morphodynamics”).

LEGAL FRAMEWORK AND EVALUATION/ ASSESSMENT CRITERIA

To a certain extent, national legislation and the national network of protected areas hitherto established in Albania constitute an important basis for the assessment of projects and the protection of sites of high biodiversity value in the country. However, additional requirements result from international conventions and, particularly, from the country's integration into the European Union. As with other fields, Albania is obliged to approximate its national legislation and assessment procedures concerning nature and biodiversity conservation with the legislation of the European Union. This chapter will not present the national regulations but will explore important international, and specifically European, legal foundations with a specific focus on assessing plans or projects for the construction of hydropower dams along the Vjosa in Albania. Subsequently, some technical evaluation foundations and criteria are briefly noted.

Birds Directive

The Birds Directive, Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds (codified version; formerly Directive 79/409/EEC) set out provisions for the species-level protection of all naturally occurring bird species in Europe, but also the obligation to designate Special Protection Areas (SPAs) for Annex I species and for other, regularly occurring, migratory bird species. These SPAs must be protected and developed by law in each member state following a specific selection process and the acceptance of the selected areas as sufficient and appropriate by the EU Commission. The SPAs become part of the EU-wide network, Natura 2000.

Habitats Directive

The Habitats Directive, Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and wild fauna and flora developed a system of strict species protection for selected species and their habitats (Annex IV) and the protection of Sites of Community Importance (SCIs) contributing to the maintenance or restoration of a favourable conservation status of natural habitat types (Annex I) or species listed in Annex II. The selection of the most suitable sites and their adoption by the EU Commission follow specific nature conservation-related criteria. An assessment is done at a national level and at an EU level. The SCIs (which become Special Areas of Conservation, SACs, after their appropriate protection under national law) become part of the EU-wide network, Natura 2000, together with the selected sites for bird protection (see above). Based on the regulations of the Habitats Directive [Article 6 (3)] an impact assessment is required for any plan or project which, either by itself or in combination with other plans or projects, is likely to have a significant effect on a Natura 2000 site.

The objective of both Directives mentioned above is to ensure the long-term survival of the represented species and habitats and to prevent declines in their populations, areas, and ranges. Plans or projects that negatively affect Natura 2000 sites (or violate prohibitions regarding protected species) can be proved to need a derogation grant or to be inadmissible.

EIA Directive

The EIA Directive, Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment (codified and amended version, formerly Directive 85/337/EEC), as amended by Directive 2014/52/EU of 16 April 2014, applies to a wide range of defined public and private projects according to the definitions in Annexes I and II. These include project types for which significant effects on the environment are expected or less expected. The first step in the decision is whether an EIA is required. The so-called 'screening procedure' uses given thresholds and criteria, or is performed as a case-by-case examination. The EIA Directive requires a developer 'to provide information on the environmental impact (EIA report – Annex IV); the environmental authorities and the public (and affected Member States) must be informed and consulted; the competent authority decides, taking into consideration the results of consultations. The public is informed of the decision afterwards and can challenge the decision before the courts'. (European Commission, Environment, 2019).

Water Framework Directive

The Water Framework Directive, Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for community action in the field of water policy, as amended by Commission Directive 2014/101/EU of 30 October 2014, comprises a number of objectives regarding the protection of aquatic ecology as a whole, and includes specific protection for valuable habitats and their biological and other components. An important aspect is the concept of 'good ecological status', that is defined in Annex V of the Directive in terms of the quality of the biological community, and the hydrological and chemical characteristics of the surface water. In this context, for example, the elaboration of river basin management plans is required. Unless a derogation is granted for an individual project, which may for example cause deterioration of the status of a surface water body or obstruct the attainment of good surface water status, the national authorities have to reject authorisation.

Eel Regulation

The European eel stock (Anguilla anguilla) is in critical condition. Recruitment is at an all-time low and the exploitation of the stock is currently unsustainable. The decline in eel stock has numerous causes, including human activities such as fisheries (commercial and recreational), hydropower turbines and pumps, pollution, habitat modification, and the creation of obstacles to eel migration. Further deterioration of the stock should be avoided. In 2007 a framework to ensure the protection and sustainable use of European eel stocks was established at the EU level (Regulation (EC) No 1100 / 2007—the so-called 'Eel Regulation'). These plans include measures to ensure the long-term escapement of at least 40% of adult eels and include: limiting professional and recreational fisheries, facilitating fish migration through rivers, and restocking inland waters with young fish.

Espoo Convention

The Convention on EIAs in a Transboundary Context, accepted at Espoo (Finland) on 25 February 1991 (Albania signed this Convention in 1991), as amended by the 2nd amendment in 2004, requires the state in which a project is planned to investigate and assess the environmental impacts of the project on neighbouring states, if this project is likely to have significant adverse transboundary environmental impacts.

Bern Convention

The Bern Convention, the Convention on the Conservation of European Wildlife and Natural Habitats (1979), signed by Albania in 1995 and entered into force in 1999, aims to ensure an appropriate level of conservation of wild plant and animal species and their habitats. Emphasis is placed on the endangered or vulnerable species, including migratory species, specified in the appendices. The parties of this Convention 'undertake to take all appropriate measures to ensure the conservation of the habitats of the wild flora and fauna species. Such measures should be included in the parties' planning and development policies and pollution control, with particular attention to the conservation of wild flora and fauna [...]' (Council of Europe, Treaty office). The setting up of ecological networks of so-called Areas of Special Conservation Interest (Emerald Network) at the national level (and subsequently as an international network), launched by the Council of Europe as part of its work under the Bern Convention, is considered one of the main tools that enable the parties to comply with their obligations.

Evaluation/Assessment Criteria

Despite the different requirements and objectives of the Conventions and Directives mentioned above, it can be stated that, as a rule, qualitative and quantitative data are needed to assess which areas are of specific conservation interest, by what means and to what extent the objects of protection and specific functions of an area are adversely affected by a plan or a project, and—where appropriate—if adequate measures for prevention and mitigation can be taken. The requirements for the quality of data and for the degree of certainty of analyses and assessments differ somewhat between regulatory areas and seem to be, after the ruling of the European Court of Justice, highest in the impact assessments for Natura 2000 sites. Some main questions are posed in chapter "Impacts on Fish".

For species and habitats, not only quantitative data are required to assess biodiversity and the possible impact of a project, but information about their distribution in the area, their sensitivity to influencing factors (and whether a species is characteristic for a habitat type), their degree of endangerment, and their conservation status is also required. Other important information includes whether there is a high responsibility to protect a specific area for the regional, national, or global survival of a species or habitat (for example, an endemic species with a small distribution), and what legal status they have. In the following chapters on plants and animals, such criteria are used. The reference works are particular Annexes of the Conventions and Directives mentioned above, the national Red List of Albania and (where available) a European or global red list. The ecological background information was sourced from the available literature and the specific knowledge of the contributors as specialists in their taxonomic groups.

Albanian legal framework affecting hydropower plant concessions

Table 1 lists 12 laws and 19 by-laws that have been identified as needing to be considered/respected for HPP concessions in the Albanian legislation. A by-laws in the form of a Decision of the Council of Ministers (DCM) is always binding.

Table 1. Albanian legal framework affecting hydropower plant concessions; DCM…Decision of the Council of Ministers.

I - CONCESSIONS/PUBLIC PRIVATE PARTNERSHIPS	
Laws	1.1. Law no. 125/2013 'On concessions and public private partnerships (PPP)', as amended
By-Laws	1.2. DCM no. 575, dated 10.07.2013 'Adoption of rules for assessment and granting of concessions/PPP', as amended
	1.3. DCM no. 576, dated 10.07.2013 'Adoption of rules for identification, assessment, and award of Hydropower Plant concessions'
II - ENVIRONMENT IMPACT ASSESSMENT AND STRATEGIC ENVIRONMENT ASSESSMENT	
Laws	2.1. Law No. 10440 on 'Environmental Impact Assessment' dated 07.07.2011, as amended
	2.2. Law no. 91, dated 28.02.2013 'On Strategic Environmental Assessment'
By-Laws	2.3. DCM no. 247, dated 30.04.2014 'On the rules, the requirements, and the procedures for public information and decision-making in the field of environment'
	2.4. DCM No. 598, dated 01.07.2015 'On the definition of rules and procedures for environmental impact assessment in a transboundary context'
	2.5. DCM no. 686, dated 29.07.2015 'On the adoption of rules, responsibilities, and deadlines for environmental impact assessment procedure and the transfer procedure of environmental statement'
	2.6. DCM No. 912, dated 11.11.2015 'On the adoption of the national methodology of the environmental impact assessment process'
	2.7. DCM no. 219, dated 11.3.2015 'On defining rules and procedures consultation with the group of interest and the public, and public hearings during the strategic environmental assessment process'
	2.8. DCM no. 507, dated 10.06.2015 'On approval of the detailed list of plans and programmes with negative impacts to the environment, that need to undergo a SEA process'
	2.9. DCM no. 620, dated 07.07.2015 'On approval of the rules, responsibilities, and detailed procedures for strategic environmental assessments in a transboundary context'
III - PUBLIC PARTICIPATION AND THE RIGHT TO INFORMATION	
Laws	3.1. Law no. 8672, dated 26.10.2000 'On ratification of Aarhus Convention "On access to information, public participation in decision-making, and access to justice in environmental matters"'
	3.2. Law no. 146/2014 'On notification and public consultation'
	3.3. Law no. 119/2014 'On the right of information'
By-Laws	3.4. DCM no. 994, dated 02.07.2008 'On engaging the public in environmental decision-making'
	3.5. DCM no. 16, dated 04.01.2012 'On the public's right to environmental information'
IV - ENVIRONMENTAL AND NATURE PRESERVATION	
Laws	4.1. Law no. 10 431, dated 09.06.2011 'On environmental protection'
	4.2. Law no. 10 448, dated 14.07.2011 'On environmental permits'
	4.3. Law no. 81/2017 'On Protected Areas'
	4.4. Law no. 10 006, dated 23.10.2008 'On the protection of wild fauna', as amended
	4.5. Law no. 9587, dated 20.07.2006 'On the protection of biodiversity', as amended
By-Laws	4.6. DCM no. 897, dated 21.12.2011 'On approval of the rules for the announcement of Special Conservation Areas'
	4.7. DCM no. 866, dated 10.12.2014 'On announcing the lists of types of natural habitats, plants, animals, and birds of interest for the European Union'
	4.8. DCM no. 419, dated 25.06.2014 'On the approval of special requirements for the examination of environmental permit applications of types A, B, and C, the transfer of permits from one entity to another, the conditions of the relevant environmental permits, and the detailed rules for their consideration by the competent authorities until the issuance of these permits by the National Licensing Centre'
V - WATER RESOURCES MANAGEMENT	
Laws	5.1. Law no. 111/2012, 'Për Menaxhimin e Integruar të Burimeve Ujore', as amended
By-Laws	5.2. DCM no. 177, dated 26.03.2014 'On the establishment, composition, functioning, responsibilities, and duties of the Special Commission on transboundary water management', as amended
	5.3. DCM no. 246, dated 30.04.2014 'On setting environmental quality norms for surface waters'
	5.4. DCM no. 267, dated 07.05.2014 'For the approval of the list of priority substances in aquatic environments'
	5.5. DCM no. 416, dated 13.05.2015 'For the approval of general and special conditions, accompanying documents, validity, authorisation, and permit application forms, review, and decision-making procedures, as well as authorisation and permit forms for the use of water resources'
	5.6. DCM no. 342, dated 04.05.2016 'On the approval of the territorial and hydrographic boundaries of the water basins in the Republic of Albania and the centre and composition of each of them'


RESULTS
PHOTO: GERNOT KUNZ

FUNCTIONAL PROCESS ZONES

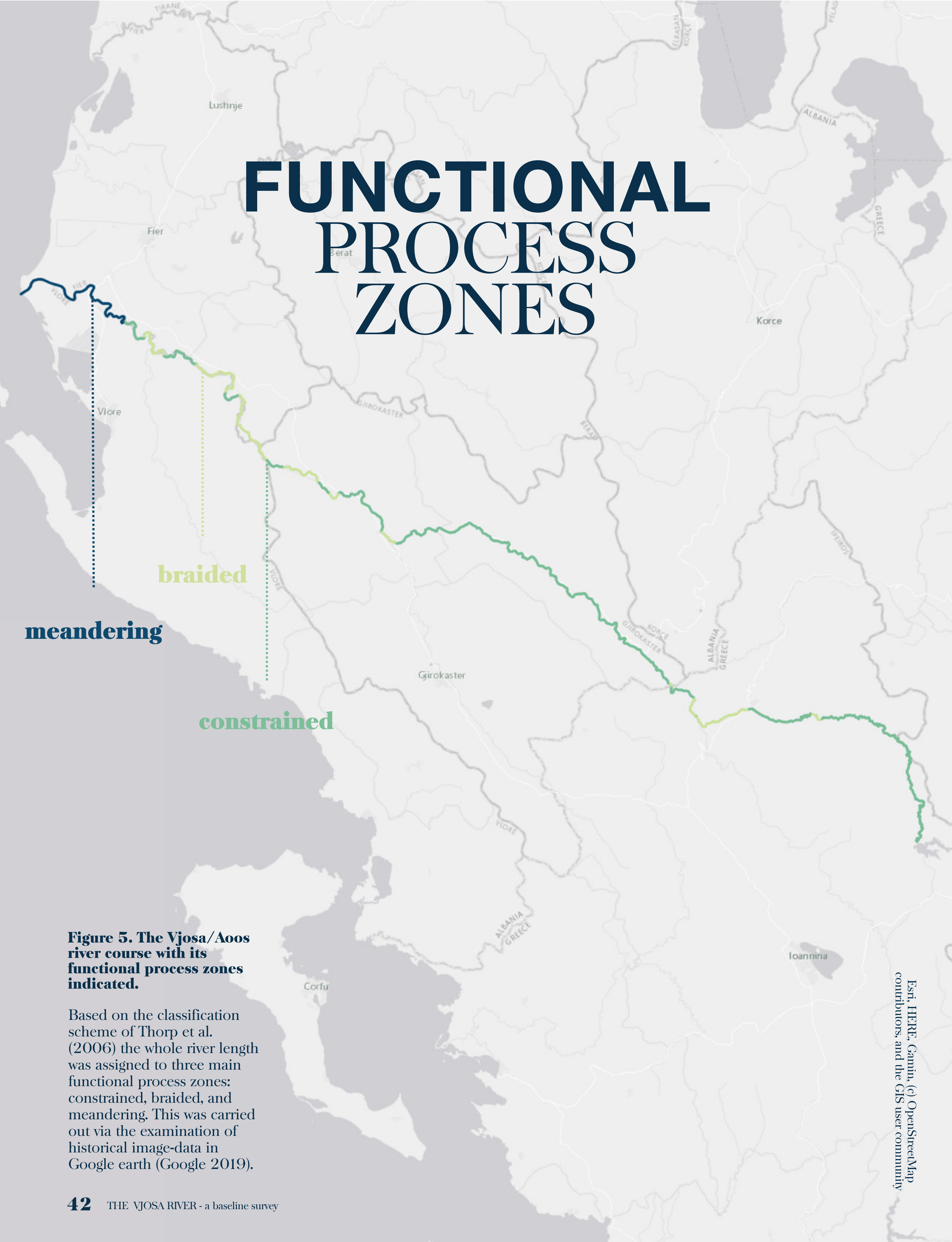


Figure 5. The Vjosa/Aoos river course with its functional process zones indicated.

Based on the classification scheme of Thorp et al. (2006) the whole river length was assigned to three main functional process zones: constrained, braided, and meandering. This was carried out via the examination of historical image-data in Google earth (Google 2019).

Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community

The slope of the river was determined with a digital elevation model, which was obtained from Copernicus Landcover Monitoring at a resolution of 25 × 25 m. In the second step, the river corridor created in ArcGIS was interpolated using the digital elevation model to receive z values for various points along the line (ESRI 2011). The next important parameter is the river width. Sites were set at 1 km intervals along the river corridor, starting from the source. At each of these sites, a line was placed at right angle to the river corridor and the active channel width was measured (compare Osterkamp and Hedman 1977). With these two factors, the river-type classifications could be cross-validated using a principal component analysis (Figure 6) performed in Rstudio (RStudio 2015).

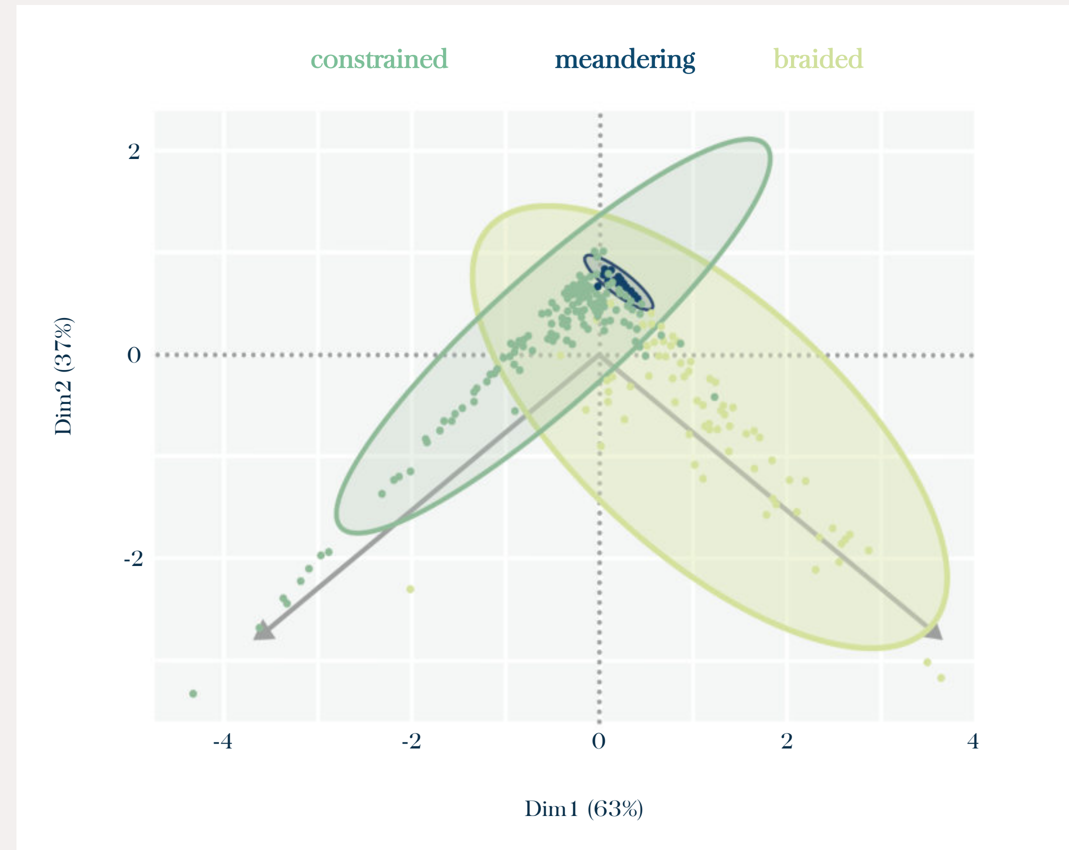
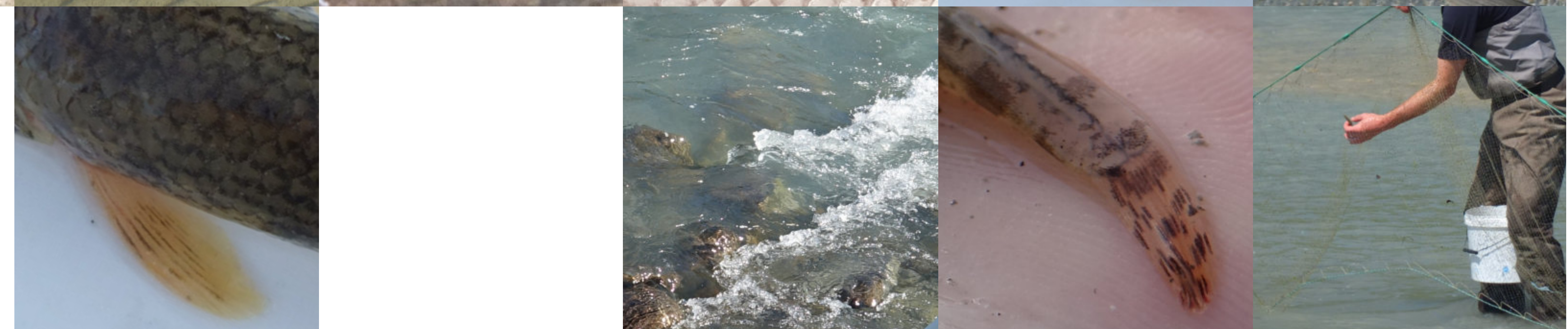
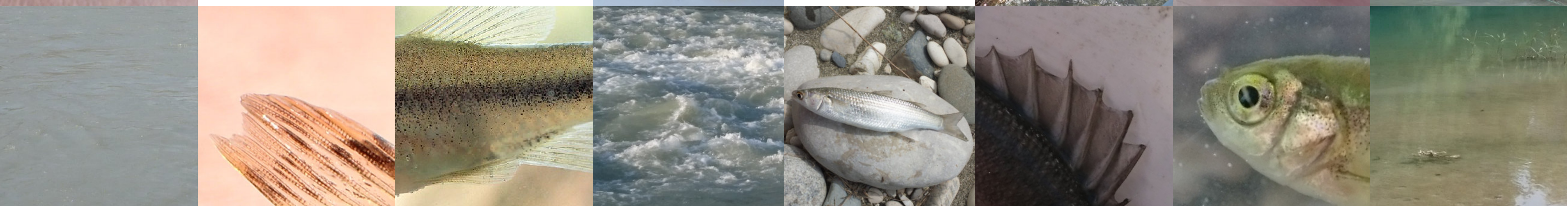


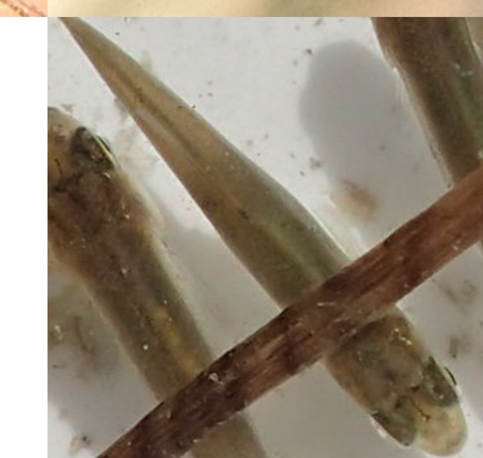
Figure 6. Principal component analysis of abiotic factors (slope and active channel width) with river-type classification. N = 266.

The principal component analysis of river-type classification with abiotic factors shows a clear pattern. While slope mainly explains the variance in constrained sections, active channel width or river width explains most of the variance in braided sections. Both factors contribute 50% to dimension 1 and 50% to dimension 2. In total, dimension 1 explains 63% of the variance while dimension 2 explains 37%. The variance in the meandering sections is explained by a combination of low slope and no variance in river width.

FISH

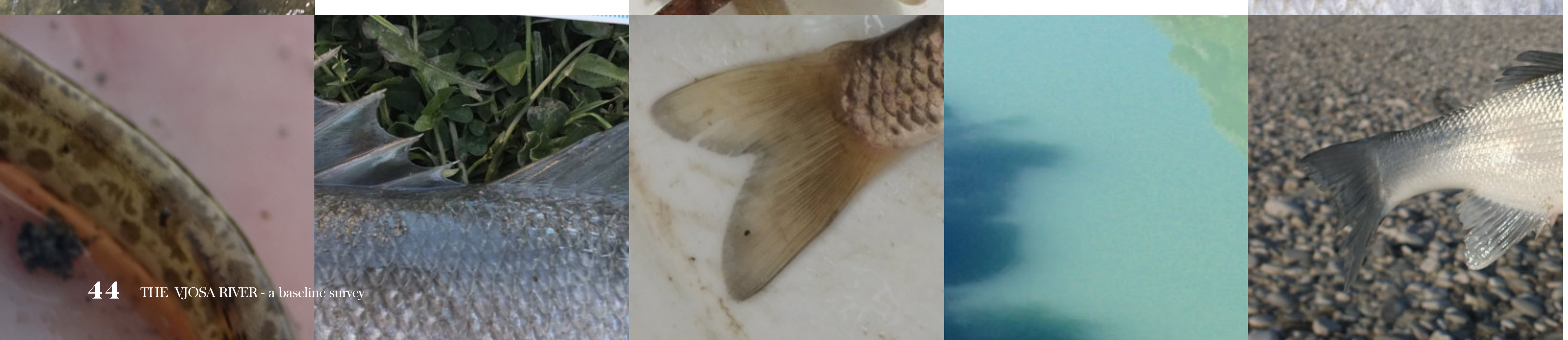


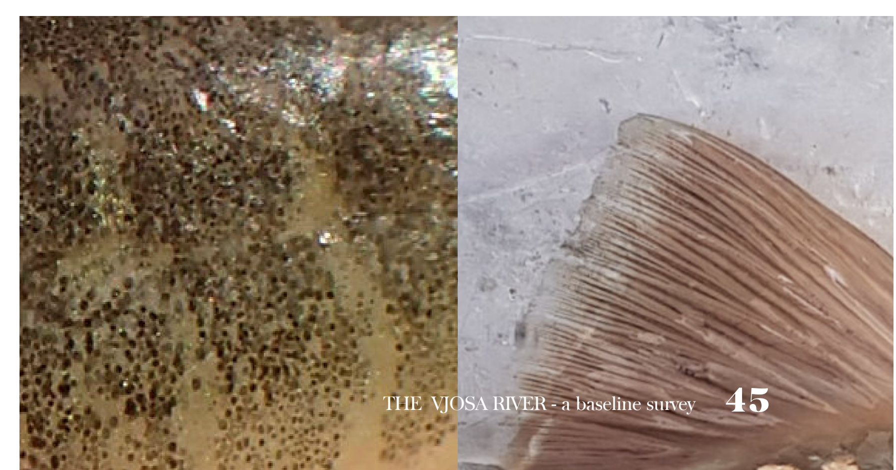


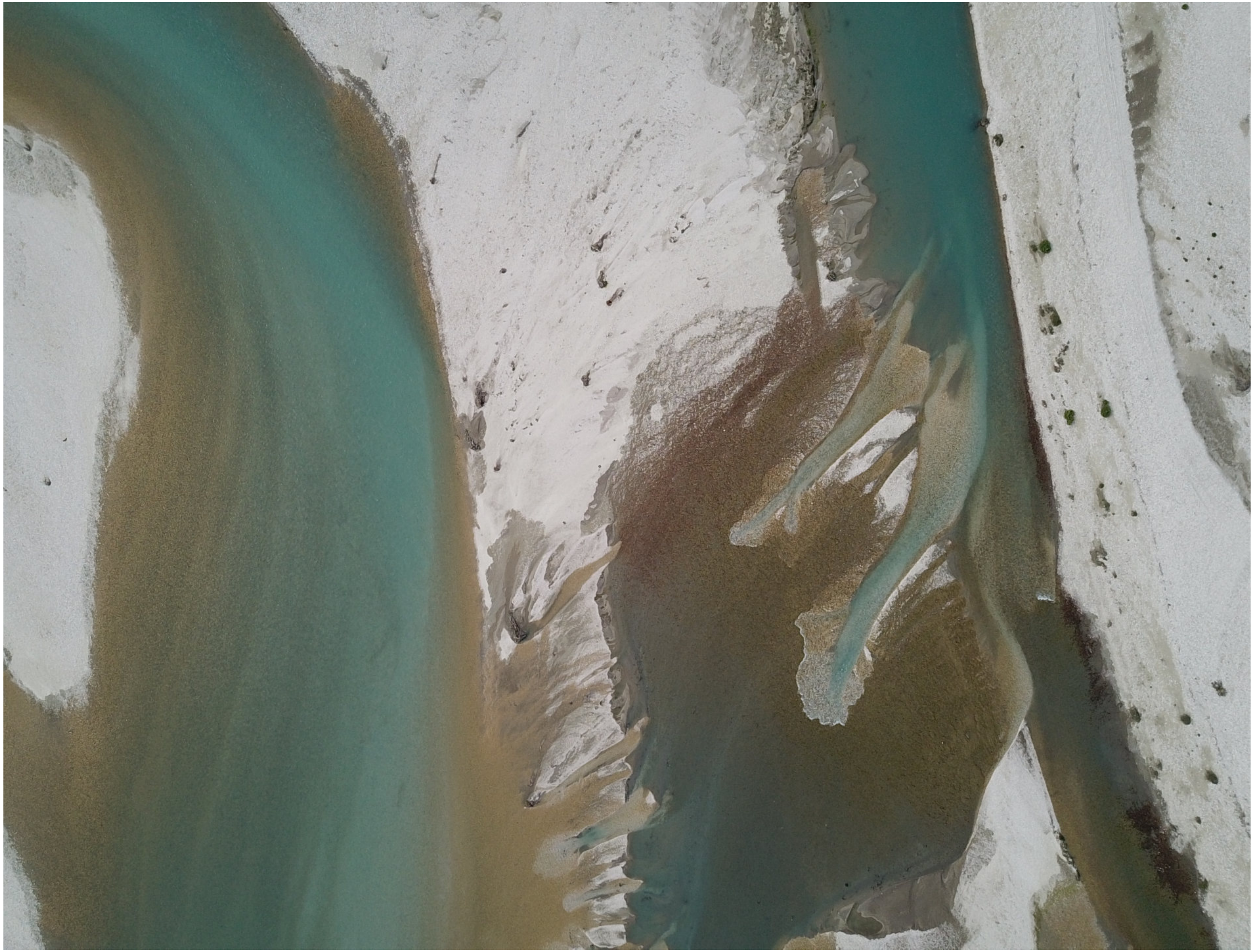


INTRODUCTION: The fish fauna of the Vjosa is of special significance and importance owing to its unique geographical and biological background. The Vjosa is one of the last medium-sized rivers with little to no anthropogenic alteration owing to hydropower production. Currently, the river course on Albanian territory has no migration barriers for fish and provides various habitats for endangered and endemic fish species (Shumka et al. 2018).

PHOTOS: **WOLFRAM GRAF/PAUL MEULENBROEK/STEFAN SCHMUTZ**







The Western Balkans have one of the largest concentrations of range-restricted species (Economouå et al. 2007) and the Vjosa stands out as a special case. It is widely undisturbed and has maintained its natural fluvial dynamics throughout its course from the headwaters in Greece (Aoos) through southern Albania (Vjosa). Thus, the Vjosa represents a model system that is typical of the dynamic floodplains that have been lost in Central Europe (Schiemer et al. 2018).

Fish are commonly used as indicators as a broad spectrum of abiotic variables of different spatio-temporal scales are linked to their habitat requirements and ontogenetic stages (Schiemer and Waidbacher 1992). Taking their ecological and behavioral preferences into account, fish species can be allocated to ecological groups (Figure 7).

Photo: Gregory Egger

1

POTAMODROMOUS fish spend their entire lifecycle within fresh water and exhibit migration to varying degrees (18 species).

Thirteen fish species in the Vjosa show distinct migration behaviour related to the sea. They are:

ANADROMOUS fish that are born in freshwater, then migrate to the ocean as larvae or juveniles where they grow into adults before migrating back into freshwater to spawn (5 species);

CATADROMOUS fish that are born in saltwater, then migrate into freshwater as juveniles where they grow into adults before migrating back into the ocean to spawn (1 species) ; and

DIADROMOUS fish for which movement into freshwater is not obligate to fulfil their lifecycle (7 species).

2

According to their general flow velocity preferences, three guilds can be distinguished:

RHEOPHILIC fish prefer to live in fast-moving water (17 species);

EURYTOPIC or indifferent fish do not show a clear preference for flowing or standing water (8 species); and

STAGNOPHILIC fish prefer stagnant water (6 species).

3

A third ecological grouping is based on reproductive strategy and spawning substrate (Balon 1975):

LITHOPHILIC species deposit eggs on rocks, rubble, or gravel substrate (14 species);

PHYTOPHILIC species scatter or stick their eggs to submerged, live or dead aquatic plants or to recently flooded terrestrial plants (5 species);

LITHO/PHYTOPHILIC species deposit their eggs on submerged plants or on other submerged items such as gravel or logs (3 species); and

PELAGOPHYLIC species release their non-adhesive eggs into open water. All these species (8 species) are related to the sea.

The guild affiliations used followed the Fame Consortium (2005), complemented by information from FishBase (Froese and Pauly 2010).

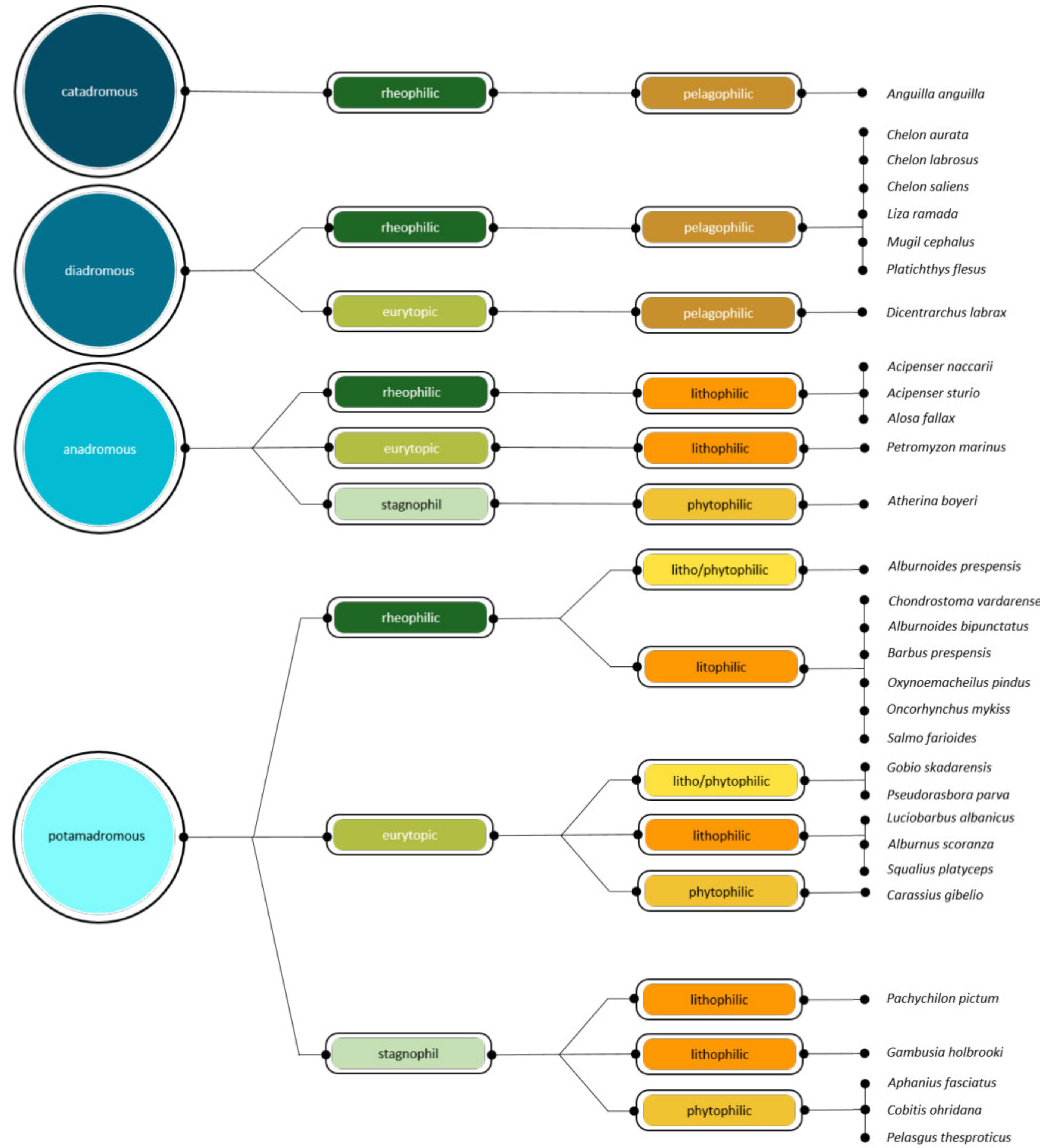
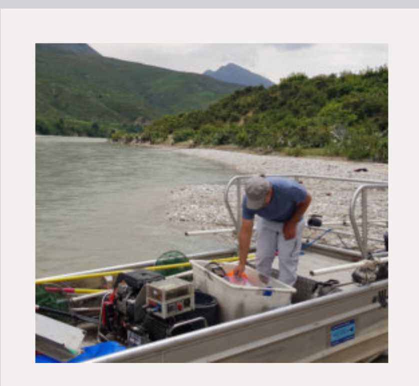


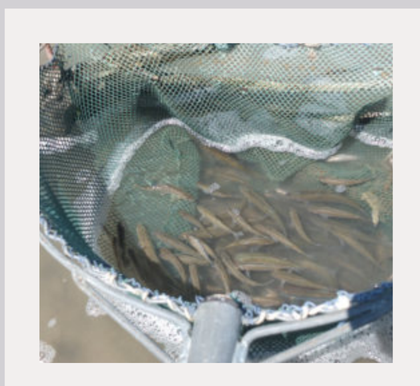
Figure 7. List of fish species in the Vjosa River and their migration, flow, and spawning guild affiliations.

This chapter gives an overview of the species caught during sampling in 2018, their distribution amongst the hydromorphological river types, and their habitats. Finally, the ecology of selected fish species are discussed and emphasis is given to the European eel (*Anguilla anguilla*).

METHODS

PHOTOS: **PROFISCH/PAUL MEULENBROEK**





Fish sampling was conducted from 23.05.2018 to 26.05.2018 by means of the so-called strip-fishing method. It is designed for sampling and calculating the fish stocks of medium-sized rivers, such as the Vjosa River. The concept is to quantify stocks by fishing a considerable amount of distinct, habitat-specific 'strips' with electrofishing-boats, and to extrapolate these samples to the whole river section according to a standardised procedure (Schmutz et al. 2001). The boats are equipped with booms of anodes mounted in front of them and hand held anode-pole. Stunned fish are caught with dip nets. In case of high densities, visible fish not caught with the dip nets are counted and added to the total catch and the catch efficiency of each strip is estimated. The fish were identified, measured, and released back into the water after each sampling strip. Fish density and biomass were calculated as the number of individuals and biomass (kg) per hectare, based on the sampled area. Sampling was performed from the city of Tepelena downstream towards the mouth of the Vjosa River (Figure 8).

Figure 8. Sampling locations in the Vjosa River (grey dots) and indicated river typology (blue = meandering, green = constrained, and light green = braided)

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RESULTS

Ecological aspects of selected fish

4
DAYS
of fishing

86
STRETCHES
were sampled

12.036
M²
fished area

18
SPECIES
were detected

2878
INDIVIDUALS
were caught and measured

6687
INDIVIDUALS
were recorded considering the catch efficiency

FIGURE 9

indicates the distribution of the different fish species along the sampled gradient of the river. It indicates slope, morphological river type, and the frequencies of selected fish species depicted as two categories ('Abundant' or 'Present').

Some species, like *Luciobarbus albanicus, Alburnoides prespensis* and *Barbus prespensis*, were more abundant in upstream sections (constrained and braided). *Pachychilon pictum, Gobio skardarensis*, and *Chondrostoma vardarense* were present in every morphological river type, although their numbers declined further downstream. *Oxynoemacheilus pindus* and *Cobitis ohridana* prefer braiding sections and do not occur in meandering sections. *Anguilla anguilla* shows a high abundance along the whole gradient. *Chelon ramada* and *Dicentrarchus labrax* showed their highest densities in the downstream, meandering sections.

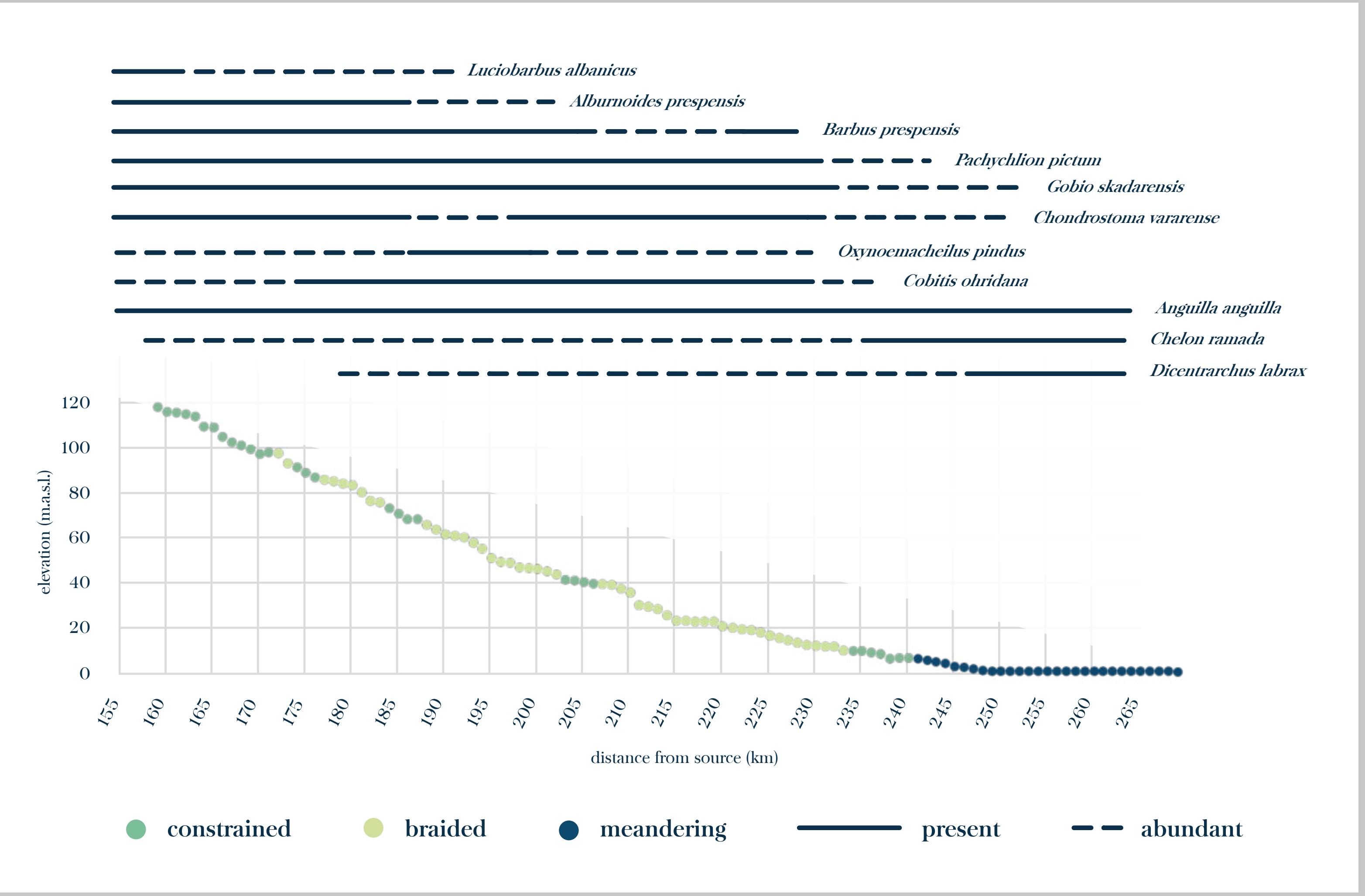


Figure 9. Schematic distribution of selected fish species along the Vjosa River downstream of Tepelena.

Table 2

indicates the mean number of individuals in each morphological river section (constrained, braided, and meandering).

Table 2. Abundance of fish in different morphological river sections in the Vjosa River; 0 = not present, 1 = low abundance (0–1 individuals per 100 m), 2 = present (1–5 individuals per 100 m), and 3 = abundant (>5 individuals per 100 m)

There is a clear distinction between species that showed a high abundance in all three sections, such as *Alburnus scoranza* and *Squalius platyceps*, species that showed a moderate abundance in all areas, like *Anguilla anguilla*, and species that were restricted to certain sections, like *Alburnoides prespensis, Barbus prespensis, Cobitis ohridana, Luciobarbus albanicus, Oxynoemacheilus pindus*, and *Salmo farioides* (constrained and braided sections). Only four species were more frequently caught in the meandering section than in the braided or constrained sections, these are *Chelon ramada, Dicentrarchus labrax, Gobiidae sp.*, and *Gambusia holbrooki*.

Species	constrained sections	braided sections	meandering sections
Alburnus scoranza	3	3	3
Squalius platyceps	3	3	3
Anguilla anguilla	2	2	2
Carassius gibelio	1	1	1
Chondrostoma vardarense	3	3	1
Barbus prespensis	2	3	0
Alburnoides prespensis	2	3	0
Gobio skadarensis	2	3	1
Pachychilon pictum	2	3	1
Oxynoemacheilus pindus	2	2	0
Salmo farioides	1	1	0
Cobitis ohridana	1	1	0
Luciobarbus albanicus	1	1	0
Pseudorasbora parva	1	0	1
Dicentrarchus labrax	1	1	2
Gambusia holbrooki	0	0	1
Chelon ramada	1	2	3
Gobiidae sp.	0	0	1

Species	cut-bank vegetated	riffle	mud/ sandbank	gravel bank	sidearm both	sidearm one	tributary
Alburnoides prespensis	2	0	3	3	3	1	3
Alburnus scoranza	2	2	3	3	3	3	3
Anguilla anguilla	2	2	1	2	0	2	2
Barbus prespensis	3	3	2	2	3	1	3
Carassius gibelio	0	0	0	1	0	0	2
Chelon ramada	0	0	2	1	0	0	3
Chondrostoma vardarense	3	1	3	3	3	0	3
Cobitis ohridana	2	0	1	0	2	1	2
Gobio skadarensis	3	2	3	3	3	3	3
Luciobarbus albanicus	2	1	1	1	0	0	1
Oxynoemacheilus pindus	0	3	0	1	0	1	3
Pachychilon pictum	3	0	3	1	3	2	3
Salmo farioides	0	0	0	0	0	0	1

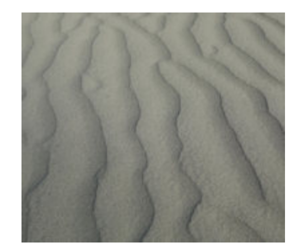
Table 3. Fish abundance in different mesohabitats of braided river sections; 0 = not present, 1 = low abundance (0–1 individuals per 100 m), 2 = present (1–5 individuals per 100 m), 3 = abundant (>5 individuals per 100 m).

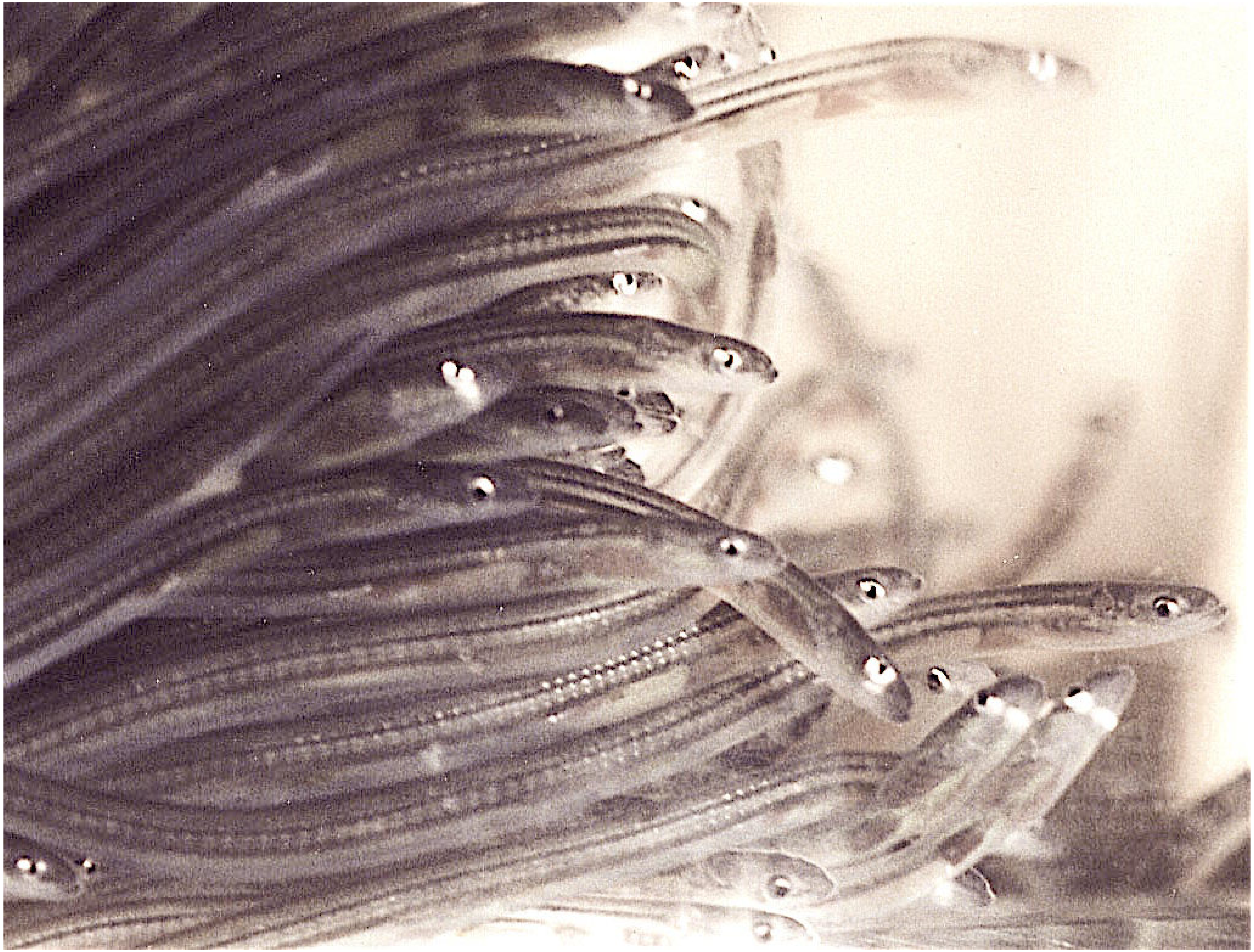
In total, 1150 fish were caught in the sampled braided sections. Some species were present in nearly all habitats (*Alburnus scoranza, Alburnoides prespensis, Anguilla anguilla, Barbus prespensis, Chondrostoma vardarense, Gobio skadarensis, Pachychilon pictum, and Squalius platyceps*), while others showed very distinct habitat preferences (*Salmo farioides, Carassius gibelio, Chelon ramada*, and *Oxynoemacheilus pindus*). The most frequented habitats, in terms of abundance, were 'mud/sand bank' (142 individuals/100 m) and 'tributary' (127 individuals/ 100 m). In terms of total species found, the most frequented habitat was 'tributary', with all 13 species that occur in the braided sections.

Table 3

lists the abundance of fish per mesohabitat in the braided sections.

PHOTOS: **GERNOT KUNZ/PAUL MEULENBROEK/STEFAN SCHMUTZ/ GREGOR SUBIC**





I

In total, the 18 verified species represent more than half of all the species that have been sampled along the Vjosa River (Shumka et al. 2018). This does not necessarily mean that the other species do not inhabit this river section, as our sampling methods were limited to the shoreline and rare species are likely to be overseen with limited sampling effort.

However, one of the species recorded in this study (*Anguilla anguilla*) is considered **Critically Endangered**, one (*Gobio skadarensis*) is **Endangered**, and a further three species (*Chondrostoma vardarense*, *Pelasgus thesproticus*, and *Oxynoemacheilus pindus*) are **Near Threatened** and Vulnerable, according to the **IUCN red list**. Three species are also listed in Annex III of the Bern convention (*Alburnoides bipunctatus*, *Chondrostoma vardarense*, and *Pachychilon pictum*).

The high abundance of European Eel within the entire sampled river stretch attracted attention (Meulenbroek et al. 2018a; Shumka et al. 2018) and will be described and discussed in more detail in the following section. The information below is partly taken from Meulenbroek et al. 2020, in which more information on this topic is available.

Photo: Uwe Kils
Source: http://en.wikipedia.org/wiki/Image:Glasseelskils.jpg

THE EUROPEAN EEL
ANGUILLA ANGUILLA

PHOTO: **OLIVIA WILFLING**

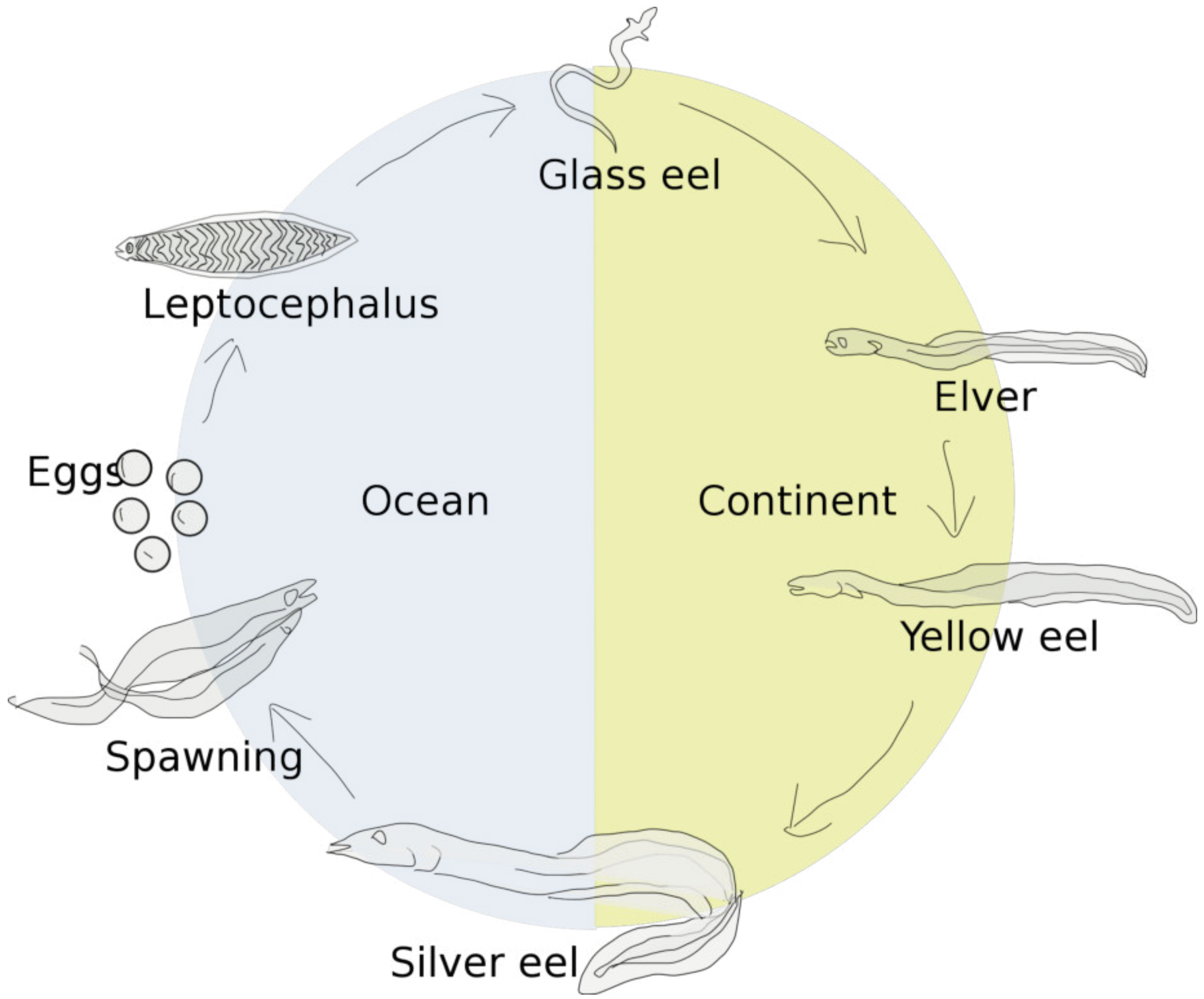


Figure 10. Life circle of eel
drawing by Salvor Gissurardottir [CC-BY-SA-2.5 https://creativecommons.org/licenses/by-sa/2.5/deed.en], via Wikimedia Commons. Available at https://commons.wikimedia.org/wiki/File:Eel-life-circle1.svg.

EUROPEAN EELS EXHIBIT AN EXCEPTIONAL LIFE HISTORY.

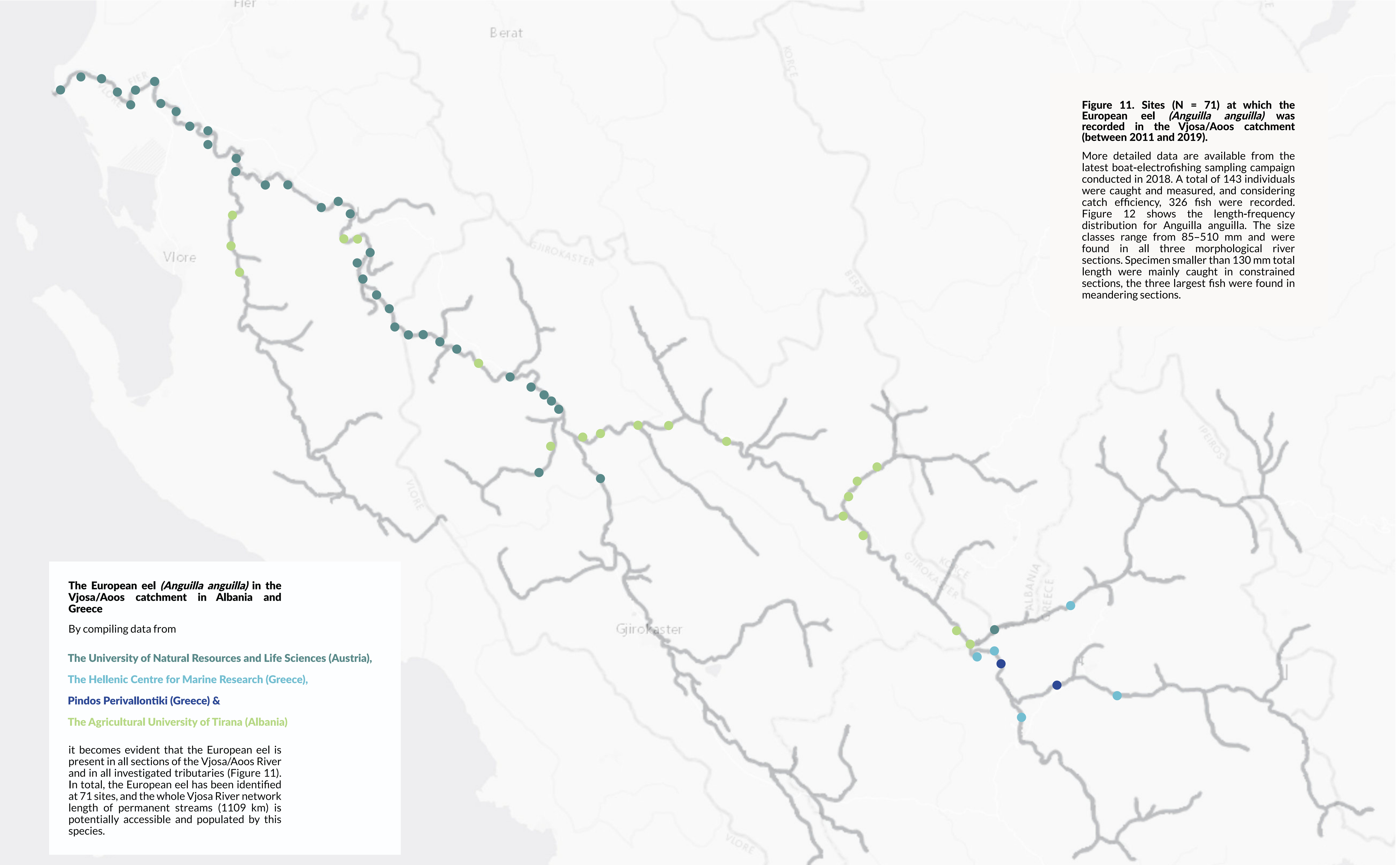
After reproduction in the Sargasso Sea (Western Atlantic Ocean), the larvae (leptocephali) arrive on the Continental Shelf of the Mediterranean Sea after 2–3 years of oceanic migration (McCleave 2003; Tesch and Rohlf 2003). After metamorphosing, the glass eel and yellow eel stages migrate upstream into rivers and mature there for three (males) to 20 (females) years. After a new metamorphosis into the sexually mature stage (silver eels), they swim downstream into the sea to migrate back to their reproductive grounds in the Sargasso Sea (Tesch and Rohlf 2003) (Figure 10).

P

Population decline and conservation status

Widely distributed throughout the European continent, the eel has been historically subjected to fishing. Over the last few decades, several studies have reported large-scale extinctions of inland stocks in rivers upstream of man-made barriers that impeded their colonisation (E.g. De Sostoa and Lobón-Cerviá 1989; Granado-Lorencio 1991). The EIFAC/ICES (2008) estimate that, because of this noticeable and prolonged decline, only 10% of the historically observed population remains.

Anguilla anguilla has already been placed on the IUCN red list of critically endangered species (Jacoby and Gollock 2014). Furthermore, the critical levels of the eel populations in Europe resulted in Regulation EC 1100/2007 (Council of the European Union 2007), requiring member states to reduce anthropogenic mortalities so as to permit the escapement to the sea of at least 40% of the silver eel biomass, relative to the best estimate of pristine escapement, i.e. the escapement that would have existed if no anthropogenic influences had impacted the stock. Today, the Mediterranean coastal habitat still constitutes a considerable proportion of the overall continental habitat of the European eel (Cataudella et al. 2014). It is suspected that the contribution of Southern European and North African countries within the Mediterranean basin can significantly impact eel global stocks (Dekker 2003). The European eel occurs in all drainages of the Albanian Adriatic and Ionian watersheds, although their numbers have decreased dramatically in recent decades. (Crivelli 1996; Rakaj and Flloko 1995).



The European eel *(Anguilla anguilla)* in the Vjosa/Aoos catchment in Albania and Greece

By compiling data from

The University of Natural Resources and Life Sciences (Austria),

The Hellenic Centre for Marine Research (Greece),

Pindos Perivallontiki (Greece) &

The Agricultural University of Tirana (Albania)

it becomes evident that the European eel is present in all sections of the Vjosa/Aoos River and in all investigated tributaries (Figure 11). In total, the European eel has been identified at 71 sites, and the whole Vjosa River network length of permanent streams (1109 km) is potentially accessible and populated by this species.

Figure 11. Sites (N = 71) at which the European eel *(Anguilla anguilla)* was recorded in the Vjosa/Aoos catchment (between 2011 and 2019).

More detailed data are available from the latest boat-electrofishing sampling campaign conducted in 2018. A total of 143 individuals were caught and measured, and considering catch efficiency, 326 fish were recorded. Figure 12 shows the length-frequency distribution for Anguilla anguilla. The size classes range from 85–510 mm and were found in all three morphological river sections. Specimen smaller than 130 mm total length were mainly caught in constrained sections, the three largest fish were found in meandering sections.

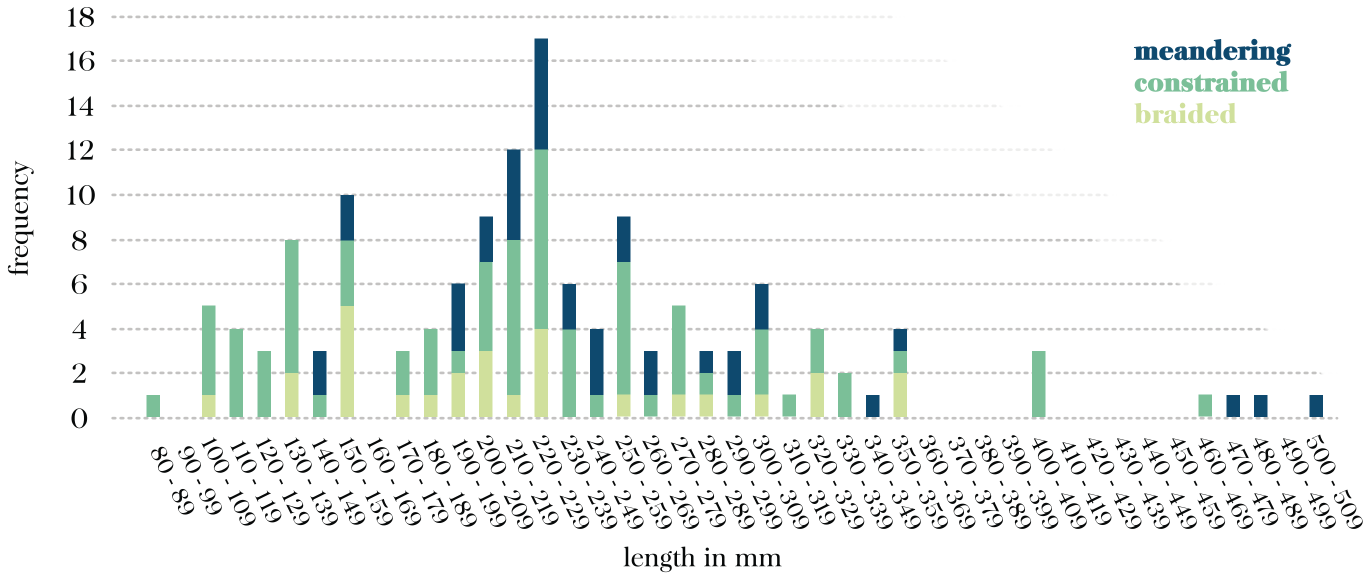


Figure 12. Length-frequency graph of *Anguilla anguilla* with total number of caught individuals (N=143) in 2018 survey, split to show the different morphological sections of the river.

Based on the conducted strip-fishing method and taking the areal share of available mesohabitats within the hydromorphological river types into account, population estimates were calculated from the quantitative eel captures. The estimates are 1.8 individuals/100 m in the braided sections, 2.5 individuals/100 m in the constrained sections, and 1.0 individuals/100 m in the meandering sections. Overall, this indicates an average of 1.9 individuals/100 m in the investigated part of the Vjosa River. The high abundance of this critically endangered species highlights the importance of the undisturbed longitudinal river continuum of the Vjosa River, at a European scale (Council of the European Union 2007; Jacoby and Gollock 2014).

Conclusion

Our results clearly show that the taxonomic composition and distribution of the fish fauna varied among the different habitats, based on the high variability of the habitat conditions (water depth, flow velocity, substrate, etc.). This is in line with a previous study conducted by Meulenbroek et al. (2018b) who concluded that different habitat types provide the basis for (1) different species and their habitat niches/requirements, (2) the changing requirements of species-specific demands to complete the life cycle (spawning ground, nursery and feeding habitats), (3) daily migration to night and feeding habitats, and (4) facultative refugia from harsh environmental conditions. A prerequisite for migration between these different habitats is a functioning connectivity at different scales.

Concerning the ecological guilds, several conclusions become apparent:

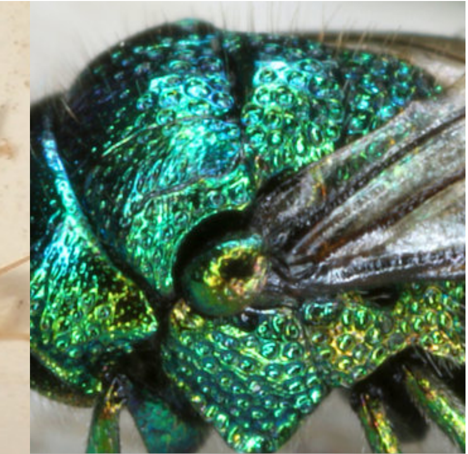
- The high numbers of anadromous, catadromous, and diadromous fish highlight the necessity of functional connectivity from the sea to the upstream river sections and back;
- The fauna in the free-flowing river is characterised by the dominance of rheophilic species, and therefore requires fast-moving water;
- All species migrate within their lifecycle to a certain extent; and
- For most species, reproduction take place on gravel substrate, hence hydrological disturbances and dynamic floods are necessary as they prevent the interstitial spaces in the sediment from clogging, which enhances the habitat not only for fish and egg development but also for other organisms, such as macroinvertebrates (Dole-Olivier 2011; Dudgeon et al. 2006).

Knowledge and understanding of the diversity of the freshwater fish fauna of a specific ecosystem is crucial for expert policymakers and natural resources managers, as well as the wider public, in order to increase understanding and evaluate the current and potential impacts of human activities on the fauna within the entire river basin.



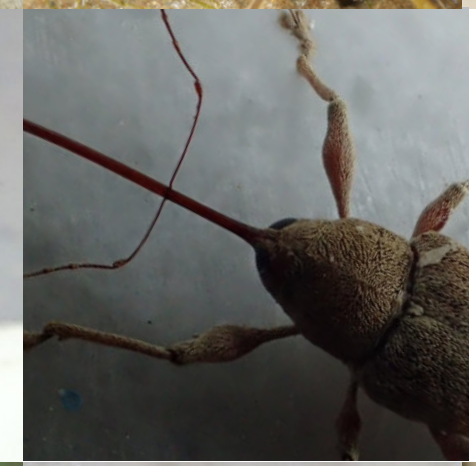
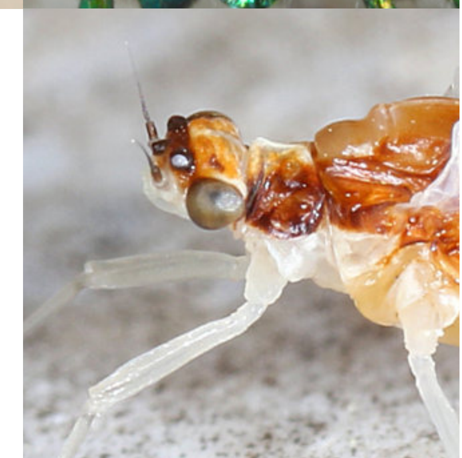





MACRO-INVERTEBRATES



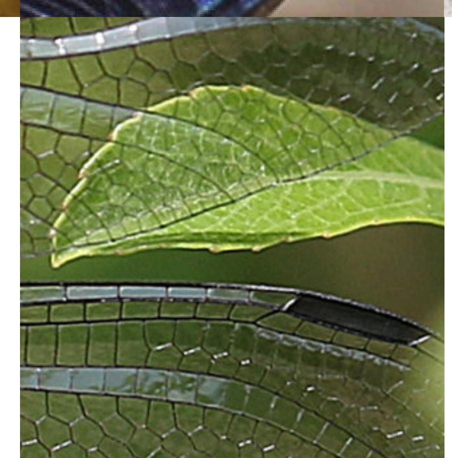











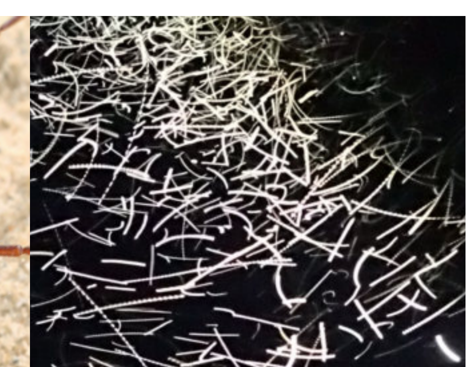
INTRODUCTION: The Macroinvertebrates are bottom-dwelling animals and consist of different organism groups including molluscs, worms, crustaceans, and insects. This heterogenous group is extremely species-rich in natural freshwater systems and several thousands of them can be found in 1 m^2 of the river bottom.

PHOTOS: **GERNOT KUNZ/WOLFRAM GRAF**









Methods

Table 4. Definitions of the flow velocity class (VC) and colmation level categories

Flow velocity class	Flow velocity (m s−1)	Colmation level	description
VC 1 (Low)	0 - 0.3	none	sediment slides under the feet
VC 2 (Medium)	Approx. 0.3 - 0.6	slight	sediment is easily penetrable with the foot
VC 3 (High)	Approx. 0.6 - 0.9	medium	sediment is hardly penetrable with the foot
VC 4 (Very high)	> 1	strong	sediment is not penetrable with the foot or tools

Different species have specific requirements regarding oxygen demand, current velocity, substrate, and food resources. Their functions are diverse, but in general they are primary consumers of microbes, algae, and other organic material. Thus, they are essential in cleaning and purifying the aquatic system. Further, they are a major food resource for fish.

Additionally, macroinvertebrate species distributions reflect historical processes, like continental drift, alpine genesis, and glaciation periods. These processes led to isolation and speciation, resulting in an extremely species-rich glacial refugia - the Balkans. Owing to their numerous specialisations and high sensitivity to environmental change, macroinvertebrates are used worldwide to assess the ecological status of freshwater systems. Stressor-specific indices or metrics have been developed to evaluate the effects of organic pollution, toxicity, pulse-release, damming, and channel straightening, among others (Birk et al. 2012; Moog et al. 2018).

Macroinvertebrates therefore

1) have the indicative power to estimate ecological status based on their community structure, according to the Water Framework Directive;

2) serve as an indicator of the biodiversity of riverine systems in general; and

3) can be used to address conservation issues, as the endemic or rare species among them are well-documented.

The sampling of macroinvertebrates was carried out in the period between 18.04. and 03.05.2018. Sampling was conducted using a 500-µm mesh-size hand net with a 0.25 m × 0.25 m frame, covering an area of 0.0625 m² per sampling unit. The Multi-Habitat-Sampling procedure was applied and consisted of 20 sampling units taken from the available microhabitat types at each sampling site. The semi-quantitative hand net was positioned facing upstream in the riverbed and the sediment in front of the frame stirred up so that the animals drifted into the collecting net (Aqem Consortium 2002). The sampled macroinvertebrates were placed in labelled containers containing 4% formalin for preservation and transportation. Additionally, the flow velocity class and colmatation status of each mineral and biotic choriotope in each microhabitat were recorded (Table 4).

The collected material was sorted and identified in the laboratory; samples were passed through a set of sieves (10 mm, 4 mm, 2 mm, 1 mm and 500 µm) under running tap water to remove the formalin and separate the size classes of benthic macroinvertebrates. The macroinvertebrates trapped in the largest sieve were sorted using the naked eye. Organisms trapped in the smaller fractions were sorted with the aid of a light microscope. Subsampling was conducted for samples with extremely high organism abundances. A fixed-fraction subsampling method was employed. The macroinvertebrates were identified to the lowest possible level and finally enumerated.

Additionally, four short-term expeditions were conducted in June 2014 (Poçem and Tepelena), in October 2016 (Poçem and Kutë), April 2017 (Kutë), and September 2017 (Kutë) to investigate the invertebrate community at the species level. The aquatic stages of the invertebrates were sampled qualitatively with a hand net while disturbing the bottom substrate. Specific habitats, like large woody accumulations or macrophytes, were sampled by hand-picking the specimens from the surface. Adults were collected by sweeping the riparian vegetation with a net and/or using light traps with different settings placed directly on the riverbanks.

The organisms were identified by the following experts: Grabowski M., Lodz, Poland-Decapoda; Hess M. and Heckes U., Munich, Germany - Coleoptera; Rabitsch W., Vienna, Austria - Heteroptera; Graf W., Vienna, Austria - Trichoptera, Plecoptera and Megaloptera; and Malicky H. and Lunz A., See, Austria - Trichoptera.

Results

PHOTOS: WOLFRAM GRAF

Diversity

In total, 227 aquatic invertebrate taxa were found along the course of the Vjosa. Taxa diversity was highest in the Trichoptera (caddisflies, 51 taxa), followed by 41 Ephemeroptera taxa (mayflies), 37 Coleoptera taxa (water beetles), 34 Diptera taxa (flies and midges), 28 Odonata taxa (damsel- and dragonflies), 10 Plecoptera taxa (stoneflies), 9 Heteroptera taxa (water bugs), 4 Crustacea taxa (scuds and shrimps), 4 Oligochaeta taxa (worms), 6 Bivalvia and Gastropoda taxa (mussels and snails), 1 Megaloptera taxon (alderflies), 1 Hydrachnidia taxon (water mites), 1 Neuroptera taxon (lacewings), and 1 Turbellaria taxon (flatworms). The total species diversity is likely much higher as larval stages cannot be identified to species level, and a more detailed survey is needed.

▼ **Photo by Gernot Kunz:** *Isoperla vjosae* ▲ **Photo by Ignaz Sivec:** *Martheamea Vitripennis*

CONSERVATION ISSUES

State of selected benthic invertebrates of large rivers in Central Europe

Large European rivers have undergone anthropogenic modification and have lost a high proportion of their indigenous fauna, especially sensitive insects like Ephemeroptera, Plecoptera, and Trichoptera. Den Hartog et al. (1992) documented the disappearance of 85% of these species in the Lower Rhine, Mey (2006) describes a similar phenomenon regarding Trichoptera, and Fittkau and Reiss (1983) more generally highlight this trend.

The national red lists of all European countries duly reflect the fact that some potamal invertebrates (i.e., taxa restricted to large downstream river sections) belong to the most endangered aquatic species on a European scale. Their decline results from many complex and interwoven factors, such as habitat degradation, organic and toxic pollution, river straightening, damming, and other hydromorphological impacts (pulse releases, residual flow), the loss of habitats such as wetlands, and population pressure by invasive species. Habitat modification rates are currently so high that virtually all natural habitats and protected areas are destined to become ecological 'islands' in surrounding wastelands of altered habitat. This process of fragmentation and isolation in landscapes under human influence - one of the main concepts in island biogeography theory - is predicted to lead directly and indirectly to accelerated species extinctions at both local and global scales, thus reducing the world's biodiversity at all levels (Lawton et al. 1995; MacArthur and Wilson 1967). In the context of the so-called 'McDonaldisation' of the biosphere (Lövei 1997), the dispersal of many species is inhibited, while others - mostly more ecologically flexible species - become common and overtake the niches of indigenous species. The replacement of vulnerable taxa by rapidly spreading taxa that thrive in human-altered environments will ultimately produce a spatially more homogenised biosphere with much lower diversity, and reduced ecosystem functioning. Regarding aquatic ecosystems and large rivers in particular, similar processes have already been observed by Fittkau and Reiss (1983); Fochetti and De Figueroa (2007); Zwick (1984, 1992).

Nowadays, already impaired potamal communities at the edge of their ecological capacity might collapse when temperature increases, amalgamating global- and climate change into a deadly anthropogenic cocktail (Travis 2003). Surprisingly, there are but few examples of decreasing species numbers with increasing habitat-related and climatic tribulations in Central European lowlands. This is because most of these communities already suffered anthropogenic impacts and now comprise reduced and rather flexible riverine and wetland assemblages. The few surviving organisms are tolerant cosmopolitans that cover large areas and multiple ecoregions.

In particular, the typical habitats of larger lowland rivers have been altered enormously within the last century by human habitat modifications. River regulations for flood protection and navigation were instigated in the second half of the 19th century, but pollution owing to industrialisation and increasing human populations, the building of HPPs, and damming opened a new chapter of river modifications. Large rivers now have completely different physical, chemical, and hydromorphological stream characteristics, including their dynamics, substrates, and flow velocities. Moreover, large rivers have been subject to invasions by non-indigenous species within the last few decades that inflict additional negative pressure on the remaining native fauna and flora. Extant populations of autochthonous potamal organisms are isolated and persist exclusively in small and severely fragmented refugia. Examples include *Marthamea vitripennis* in the Lafnitz/ Raaba and Theiss/ Tisza Rivers in Hungary (Kovács and Ambrus 2000), and the majority of the species listed below, as demonstrated and reported in many studies (Fittkau and Reiss 1983; Fochetti and De Figueroa 2007; Zwick 1984, 1992). The faunal assemblage recorded from the Vjosa is typical for natural large rivers that once covered large areas across Europe. Rigorous river basin management actions and the strict prohibition of further anthropogenic impact may conserve the legacy of the Vjosa for future generations, but they would need to be implemented and fully observed soon. Among the highly diverse benthic community found at the Vjosa, there are several rare and endangered species. The following five selected invertebrate species inhabiting the Vjosa are an exemplary illustration of this fact --»

Marthamea vitripennis (Plecoptera: Perlidae) and *Xanthoperla apicalis* (Plecoptera: Chloroperlidae)

Both predatory species were once typical inhabitants of large rivers in Europe. Zwick (1984) registered 'a dramatic decline of the species practically everywhere in central Europe' regarding *M. vitripennis*. The same is true for *X. apicalis*, which lost a considerable proportion of its range owing to anthropogenic effects. The Vjosa apparently provides suitable habitat for these plecopterans, as numerous larvae were found on the river bottom. As in many species, we know very little about their ecological prerequisites, and intensive autecological studies could provide crucial baseline information to enhance management plans in Central Europe.

Isoperla vjosae (Plecoptera: Perlodidae)

This species was collected for the first time during the Vjosa Science Week in April 2017 that was initiated by Riverwatch and supported by private funds. *I. vjosae* was only described recently (Graf et al. 2018) and is known worldwide exclusively from the Vjosa at Kutë. As all the systematically closely related species from the tripartite group are known from montane and sub-montane headwaters, the species is most likely adapted to the highly dynamic conditions presently occurring in the Vjosa. Any environmental changes obstructing these dynamic, gravel-shifting conditions will seriously endanger this rheobiont species, leading to the worldwide extinction of this particular Albanian Plecoptera species.

Prosopistoma pennigerum (Ephemeroptera: Prosopistomatidae)

P. pennigerum is a small Ephemeroptera with a larval body size of up to 6 mm and a peculiar larval morphology, indicating a derived evolutionary lineage within the order. Little is known about the ecology of this enigmatic species and very little material is available (Bauernfeind and Soldán 2012; Schletterer et al. 2015). Molecular analysis indicates that the only known populations since 2010, in the Volga and Vjosa Rivers (Schletterer et al. 2018), share identical haplotypes of partial mtCOI sequences. Larvae were found on cobbles in the Vjosa at Poçem and Kutë, in flow velocities between 30 and 100 cm/s, and the species is reported to occupy similar habitats in the Volga River. River damming would lead to the extirpation or extinction of these particular populations. In the Daugava River, for example, the species disappeared after the building of a HPP dam (Schletterer and Kuzovlev 2007). Schletterer and Füreder (2009) summarise the ecological situation of this Ephemeroptera family as follows: 'the records are scattered, and some species were only found once and not rediscovered after their description. Obviously, Prosopistomatidae are an extremely rare and sensitive family, which underlines the need for the specific protection of all species, i.e. their inclusion on the IUCN list (Schletterer and Füreder 2008). For example, the species *P. pennigerum* became rare throughout Europe owing to an increase of anthropogenic activities, i.e. habitat alternation and/or eutrophication, within the 20th century' (Schletterer and Füreder 2009). As numerous specimens can be found in the Vjosa, the urgently needed studies on the ecology of *P. pennigerum* could be conducted in this last persisting European population. Despite its small body size, it has the potential to become a flag-ship species for natural lowland river systems.

Potamophilus acuminatus (Coleoptera: Elmidae)

Buczyński et al. (2011) state that 'in many countries *P. acuminatus* is regarded as a species strongly endangered by extinction'. In Austria, the Czech Republic, Germany, and Slovakia it has the status CR (critically endangered) (Farkač et al. 2005; Geiser 1998; Holecová and Franc 2001; Jäch et al. 2005) owing to strong decreases of national populations in relation to historical data, including the regional extinction of the species (Klausnitzer 1996), or its long-term, country-wide absence (Boukal et al. 2007). The decline of *P. acuminatus* in Europe has many causes, such as water pollution and degradation, and the development of banks (Klausnitzer 1996). Braasch (1995) for example, classified it in the highest sensitivity class regarding environmental degradation. Jäch et al. (2005) report, among others, that because of this species' high requirements regarding water quality and its low resistance to organic and toxic pollution, 'adverse changes of the environment result in the decrease of numbers and quality of habitats of *P. acuminatus* as well as their fragmentation (Ribera 2000). A specific threat is associated with the trophic requirements of the larvae: the harmless removal of decaying wood (its main habitat) can result in the total vanishing of the species (Jäch et al. 2005). For the reasons described above, the authors postulate the inclusion of *P. acuminatus* in the IUCN Red List in the category VU (vulnerable species) (Jäch et al. 2005; Ribera 2000).

1

Marthamea vitripennis **(Plecoptera: Perlidae)**

PHOTO: **WOLFRAM GRAF**

2

Prosopistoma pennigerum **(Ephemeroptera: Prosopistomatidae)**

PHOTO: **WOLFRAM GRAF**

3

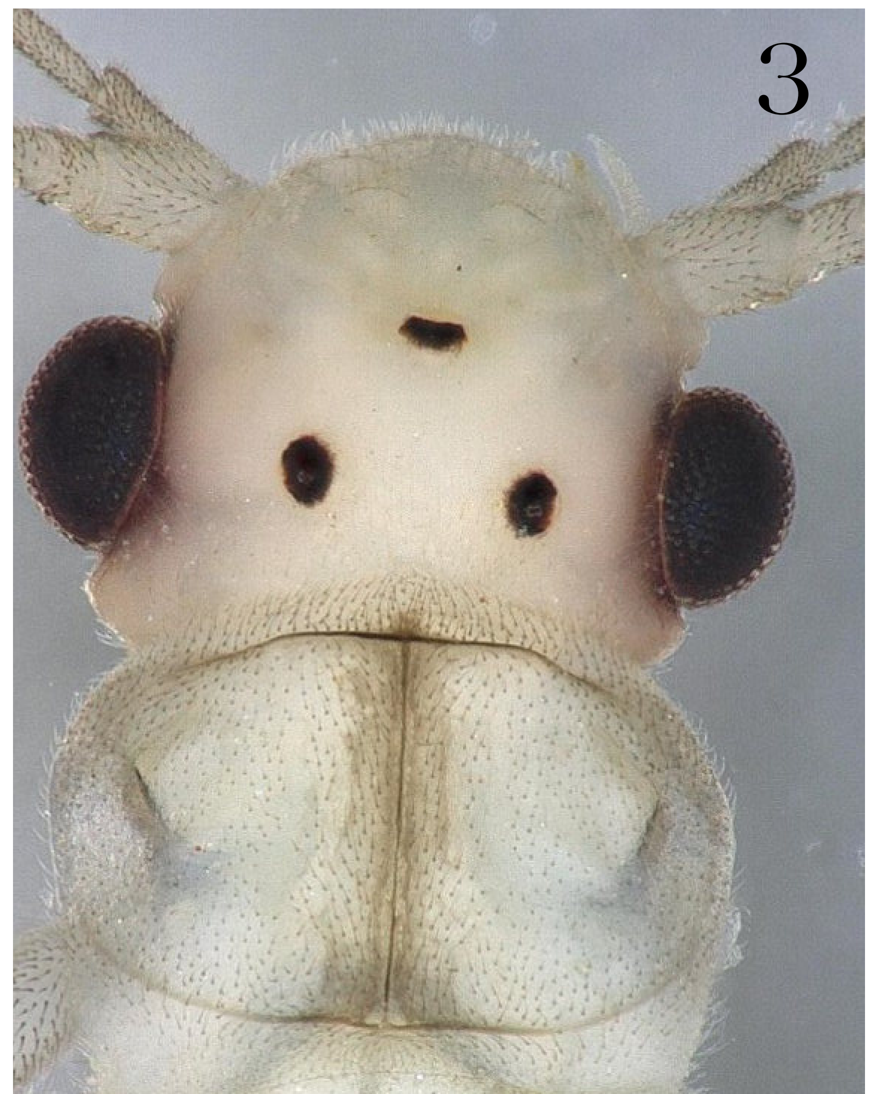
Xanthoperla apicalis **(Plecoptera: Chloroperlidae)**

PHOTO: **WOLFRAM GRAF**

4

Potamophilus acuminatus **(Coleoptera: Elmidae)**

PHOTO: **WOLFRAM GRAF**



CONCLUSION

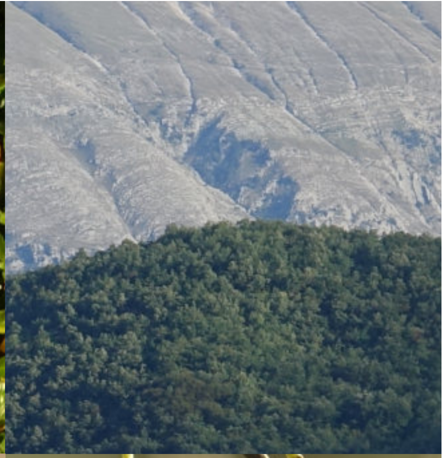
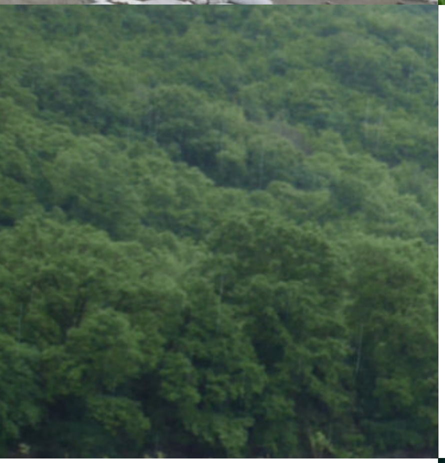
PHOTO: **WOLFRAM GRAF**

The fauna of the Vjosa comprises typical elements of highly dynamic large rivers, all of which have lost large areas of their former distributions in Europe. These riverine faunal elements are extremely sensitive to changes of the natural hydromorphology. Any anthropogenic alterations of this special habitat, like changes in discharge and flow regimes or in sediment budget, will affect this specialised assemblages. Most likely, these highly vulnerable taxa will decrease in population density, or will go extinct. Since the benthic communities of Albanian and Balkan fauna and flora are poorly known, no one can tell if this unique diversity occurs in other areas, and how it will respond to large-scale hydromorphological changes. Yet one thing is certain: any changes in this system that deprive it of its dynamic character will lead to a loss of biodiversity. With the obliteration of the typical faunal community of this last undammed large European river, the unique opportunity to study such systems will be lost. In light of on-going restoration measures aimed at mitigating global change, the significance of such untamed rivers as models to guide restoration efforts cannot be undervalued. The Vjosa and her highly diverse floodplain, in particular, could serve as an example of the large gravel-shifting rivers that were once common in Europe.

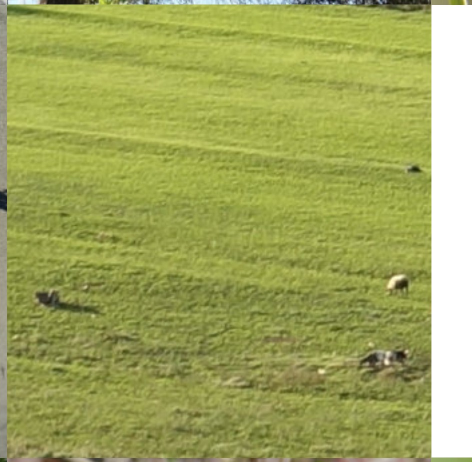


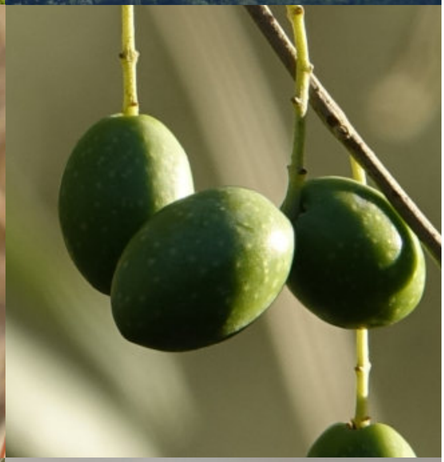
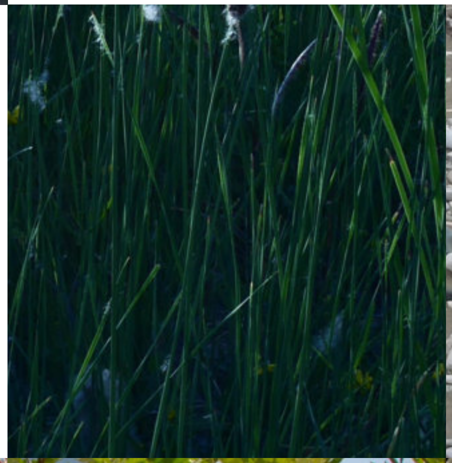


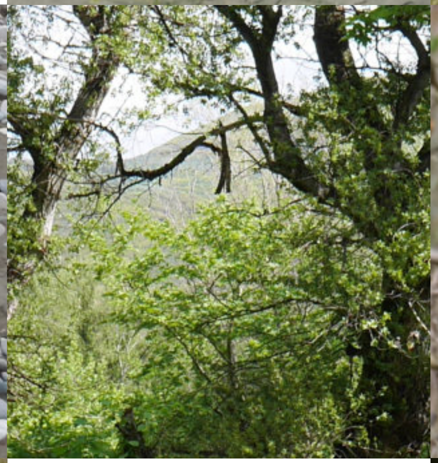


FLORA AND VEGETATION





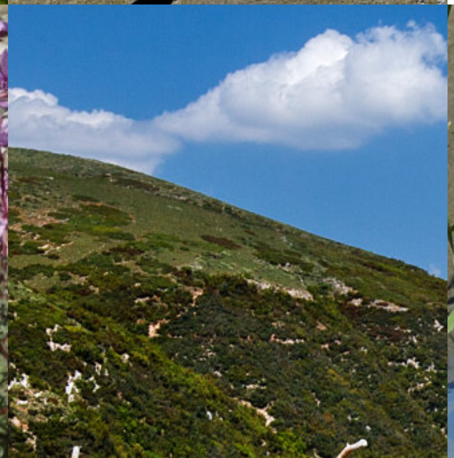


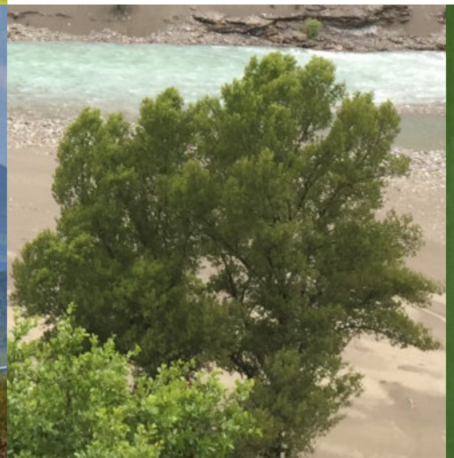


INTRODUCTION: Riparian habitats are characterised by their large numbers of endangered and protected plant species and communities at national and international levels. They are adapted to specific site conditions and are therefore suitable as indicators of short-, medium- and long-term changes in site conditions. In a detailed study, Egger et al. (2019) investigated the vegetation patterns and riparian habitats at Poçem and upstream of Kalivaç. In the following pages, the methods and selected results are summarised and the conclusions are presented.

PHOTOS: **ANTON DRESCHER/GERNOT KUNZ/MARLENE RANDL/STEFAN SCHMUTZ**






METHODS

PHOTO: **STEFAN SCHMUTZ**

In April and September 2017, and in May 2019, vegetation data and selected site parameters from more than 90 plots (vegetation relevés) were collected along the Albanian Vjosa and some of its tributaries. Plot size varied from 25 to 100 m², depending on the sampled vegetation type. The standardised area for biological soil crusts was 1 m², for pioneer vegetation and shrub it was 10–25 m², and for woodland patches 100 m². To estimate the cover or abundance of all registered species in a plot we used the nine classes of the extended Braun-Blanquet scale (Reichelt and Wilmanns 1973). As a basis for the assignment of vegetation types/succession stages to habitat types, a number of habitat parameters, like substrate, distance from the main water course, density and height of vegetation, and dominance of herbs or woody species, were noted. For the identification of vascular plants we used Flora Europaea (https://eunis.eea.europa.eu/references/1780/species) and Pils et al. (2016). Data were imported into the database management system TURBOVEG (Hennekens and Schaminée 2001), for data processing, and imported from there into JUICE (Tichý 2002), a tool for the analysis of vegetation and ecological data. The data of all relevés were classified with TWINSPAN (Hill 1979). Based on current aerial pictures (Esri), the vegetation types were mapped between Poçem bridge and Memaliaj bridge from 9 May to 23 May 2019. The pre-defined vegetation types were organised into succession phases. The documentation of the vegetation types was conducted across the whole morphological floodplain throughout the investigation area.

The available historical maps of the Vjosa from 1968, 1980, and 2016 differ in resolution and quality. Consequently, the vegetation types are not consistent. The basis of the 2016 historical map is merged aerial pictures from Google Earth from 29 September and 25 October 2016. The basis of the 1980 historical map is a detailed topographic map from 1980 (Kesh & Sogreah Consultants 2008) complemented by a different topographic map from 1985 (Ministry of Defense (Ministria e Mbrojtjes) 1985). As the topographical maps give less information than the aerial pictures, the vegetation types had to be simplified. The 1968 historical map was declassified based on CORONA satellite images (USGS 2018) which were taken on December 22nd 1968. The images are black and white, but are relatively good quality as there is almost no cloud cover.

The ecotope changes between different years are classified according to their main processes (progression, regression, stability, and anthropisation) and their sub-processes. The changes in short-term processes (2016–2019) are analysed with more focus on sub-processes. The mid- and long-term processes were categorised into combined types (main processes).

The different intersections are:

Short-term processes (‹ 5 years): time series analyses between 2016–2019 (3 years)

Mid-term processes (5–20 years): time series analyses between 1968–1980 (12 years)

Long-term processes (› 20 years): time series analyses between 1980–2019 (39 years) and 1968–2019 (51 years)
All definitions and details of the applied methods are described and listed in Egger et al. (2019).

RESULTS

PHOTO: **GERNOT KUNZ**

The species surveys along the Vjosa (10–130 m a.s.l) and the Sarandoporo (around 340 m a.s.l) identified more than 350 species, which is more than 10% of the total Albanian flora species count in only 0.1% of the total area of the country.

The most common species in the Vjosa floodplain are the characteristic woody species of Mediterranean floodplain ecosystems, like *Platanus orientalis, Salix alba, Vitex agnus-castus, Tamarix parviflora,* and *Salix amplexicaulis.* Among the herbs, pioneer species like *Cynodon dactylon, Agrostis stolonifera, Chondrilla juncea,* and *Elytrigia/Elymus spp.* are dominant. Within the Vjosa floodplain, neophytes are a neglectable factor.

The following vulnerable species are relatively common in the floodplain: *Platanus orientalis* and *Populus alba* (usually shrubby, rarely as a tree); while *Salix triandra, Ulmus minor,* and *Iris pseudacorus* (only in Alnus swamps) are rare to very rare. The Typha species *T. shuttleworthii* (endangered) and *T. minima* (critically endangered) are known only from a few stands (IUCN Standards and Petitions Committee 2019).

In the mapped area of the morphological floodplain (100%, 3142 ha), the main and side arms of the Vjosa occupy approx. 17% (526 ha); Of the colonisation stages, the vegetation-less gravel, sand, and silt initial phases cover approx. 7% (213 ha) and the young pioneer stages approx. 20% (644 ha). The shrub phases are closely linked to these very young phases, and cover 12% of the area. A cogon-grass grassland, which occupies extensive areas (approx. 17%, 527 ha), is mostly found in areas 1 to 3 m higher within the floodplain. These areas with low morphodynamics are potential forest areas, but owing to periodic fire, grazing and logging by sheep and goats they are mostly open grasslands with areas of upcoming shrubs (secondary succession). Natural alluvial forests only occur in small areas. In total, 19 vegetation types were identified. Of the floodplain, 74% is natural or near-natural areas and 26% is affected by anthropogenic impacts. These are arable lands in peripheral areas (22%, 683 ha): extensive pastures (4%, 117 ha) and agriculture fields.

The comparison of vegetation between 1968, 1980, 2016, and 2019 shows a typical long-term picture for (nearly) natural gravel-bed rivers. The river and colonisation stages cover the largest part of the morphological floodplain, with a percentage of 40 to 60. The young transition stages (herb and shrub phases) also account for a considerable portion (between 13 and 30%). Only the riparian forest is smaller than expected in natural riparian ecosystems, with a fraction of 1 to 8%. In addition, a continuous decline can be observed here over the last few decades. The area that has been affected by human use has remained almost unchanged (at approx. 25%) over the last 50 years.

Successional processes

The morphological floodplain of the Vjosa is characterised by exceptionally high naturalness. This is underlined by the analysis of the following processes:

Progression and regression occupy comparable areas in all time periods. These amount to 20 to 30% of the total area over a period of 10 to 50 years, which is a typical value for the upper and middle reaches of natural rivers (historical upper Isar: 35% progression, 28% regression; historical upper Rhine: 16% progression, 14% regression; Allier: 13–30% progression, 10–23% regression).

The proportion of the relocated areas (progression and regression) is relatively high, covering about 45 to 60% of the total area of the morphological floodplain. Areas showing the same processes at the two different points in time accordingly account for 40 to 50% of the total; only within the shortest period of 3 years (2016–2019) was 78% naturally unchanged.

It is particularly noticeable that the proportion of regression area is generally somewhat higher than that of the progression area when viewed in detail. This underlines the extremely variable hydromorphodynamics of the Vjosa in the study area.

In addition, young succession phases are predominantly affected, which is very typical of natural gravel-bed rivers.

The land loss of natural floodplain areas owing to intense agricultural use (progression: any natural phase agriculture) is relatively moderate from a mid- to long-term perspective (approx. 5%). In contrast, natural river dynamics lead to the loss of about 3 to 4% of arable land (regression: cultivated land any ecotope). Thus, the loss of arable land is almost balanced.

The proportion of cultivated land is very low for a river floodplain within a cultivated landscape (only 20% of the morphodynamic floodplain area). The agriculturally more intensively used area is limited to the peripheral and higher areas of the floodplain. In this context, it should be emphasised that in comparable gravel-bed rivers in Europe, most of the potential floodplain has been drained by the river after correction and is used as arable land for centuries.

Only the progression towards floodplain forests is negligible. The natural process of re-wooding is largely prevented by regular fires. In addition, the grazing of the areas with sheep, and especially goats, delays the natural development of woody plants. In addition, the (relatively small) proportion of floodplain forests has been continuously reduced by deforestation over the past decades.

The majority of the Cogon-grass grassland (446 ha, almost 90%) occurs at a higher level and is classified here as a ‘degradation stage’ of floodplain forests (potential floodplain forest area). This proportion (approx. 15%) is more than 10 times higher than the remaining proportion of riparian forest (1.34%).

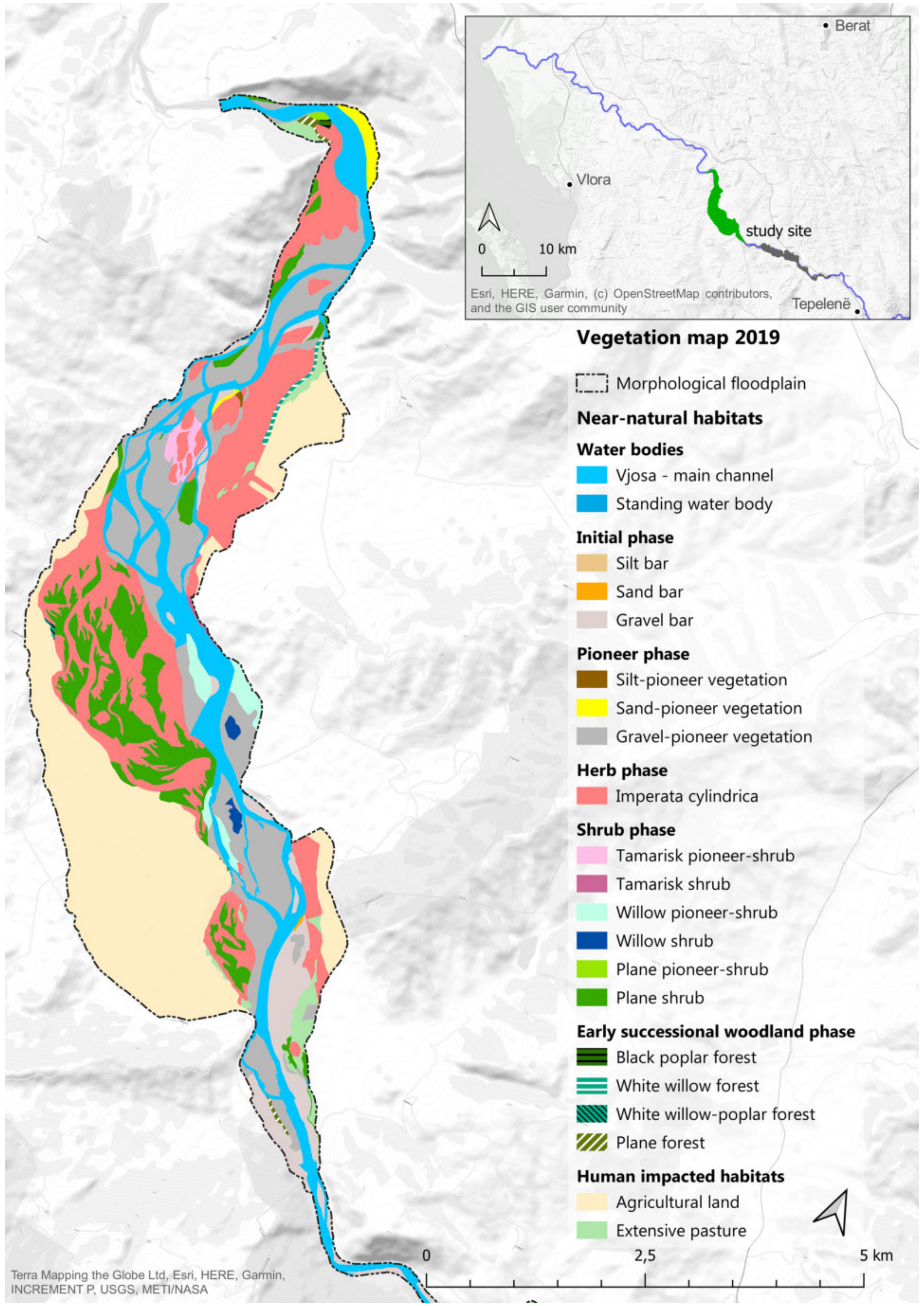


Figure 13: Vegetation map 2019, Part 1, Western part near Poçem (Randl in prep.).

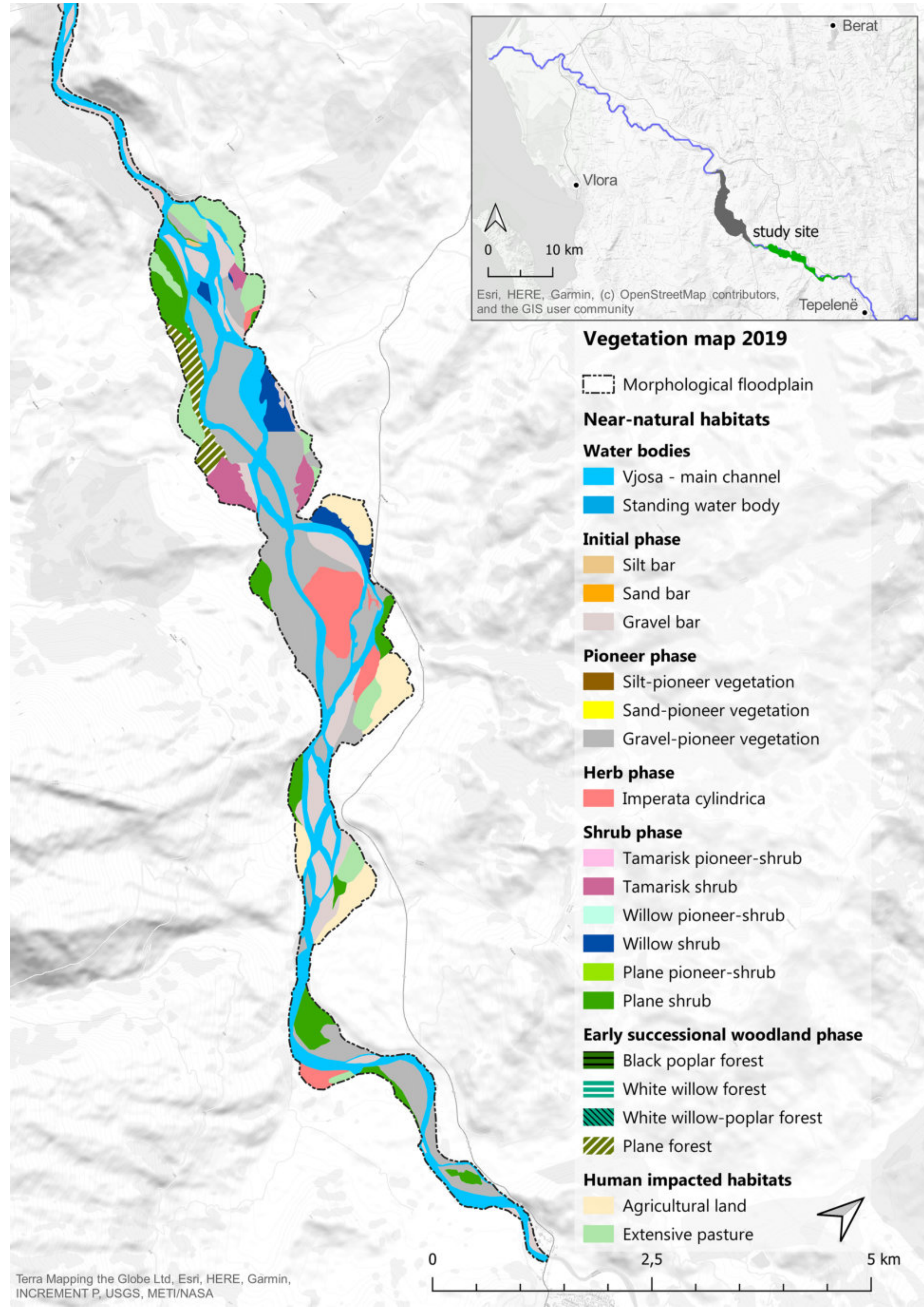


Figure 14: Vegetation map 2019, Part 2, Eastern part upstream of Kalivaç (Randl in prep.).

Habitat Directive

PHOTOS: **STEFAN SCHMUTZ**

Table 5: Habitat-Directive habitats in the floodplain zone in 2019 in ha and % modified from Randl (in prep.)

Habitat type	Description	ha	%
Vjosa (3220, 3250)	Water body/Running Water	527,95	16,78
3220	Alpine rivers and the herbaceous vegetation along their banks (note: no streams with an alpine, summer-high flow regime)	216,3	6,87
3250	Constantly flowing Mediterranean rivers with *Glaucium flavum*	643,9	20,46
3230	Alpine rivers and their ligneous vegetation with *Myricaria germanica*	44,77	1,42
3240	Alpine rivers and their ligneous vegetation with *Salix eleagnos*	66,06	2,1
92D0	Southern riparian galleries and thickets (Nerio-Tamaricetea and *Securinegion tinctoriae*)	277,24	8,81
6210	Semi-natural dry grasslands and scrubland facies on calcareous substrates	526,65	16,74
9,10E+01	Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (Alno-Padion, *Alnion incanae*, *Salicion albae*)	7,81	0,25
92C0	*Platanus orientalis* and *Liquidambar orientalis* woods (*Platanion orientalis*)	34,23	1,09
	FFH-Habitats	**2344,91**	**74,52**
	Non-Habitat-Directive-relevant areas	**801,79**	**25,48**
	Total sum	**3146,7**	**100**

The map of the respective natural habitat types of the Habitat Directive from 2019 shows eight different types covering a total of 75% (2345 ha) of the total study area. The highest percentage (20%, 644 ha) is covered by type 3250 - Constantly flowing Mediterranean rivers with *Glaucium flavum*. The second largest proportion is of type 6210 - Semi-natural dry grasslands and scrubland facies on calcareous substrates. The following four types together make up a proportion of less than 5%. They are only located in small areas but these areas are distributed throughout the investigation area: 3230 - Alpine rivers and their ligneous vegetation with Myricaria germanica (1.42%), 3240 - Alpine rivers and ligneous vegetation with *Salix eleagnos* (2.1%), 91E0 - Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (0.25%), and 92C0 - *Platanus orientalis* and Liquidambar orientalis woods (1.09%). The 'running water' habitat types of the Habitat Directive include sections of water courses with natural or semi-natural dynamics where the water quality shows no significant deterioration (European Commission 2007). In the Vjosa, the river areas bordering the river channels are assigned the FFH types 3220 and 3250 (Figure 15, Figure 16). The investigated area at Poçem and Kalivaç, which represents the region of the planned HPP, covers 2345 ha (1817 ha semiterrestrial and terrestrial habitats + 528 ha wetted areas of the Vjosa) of habitat listed in the Framework of the Habitat Directive (Table 5).

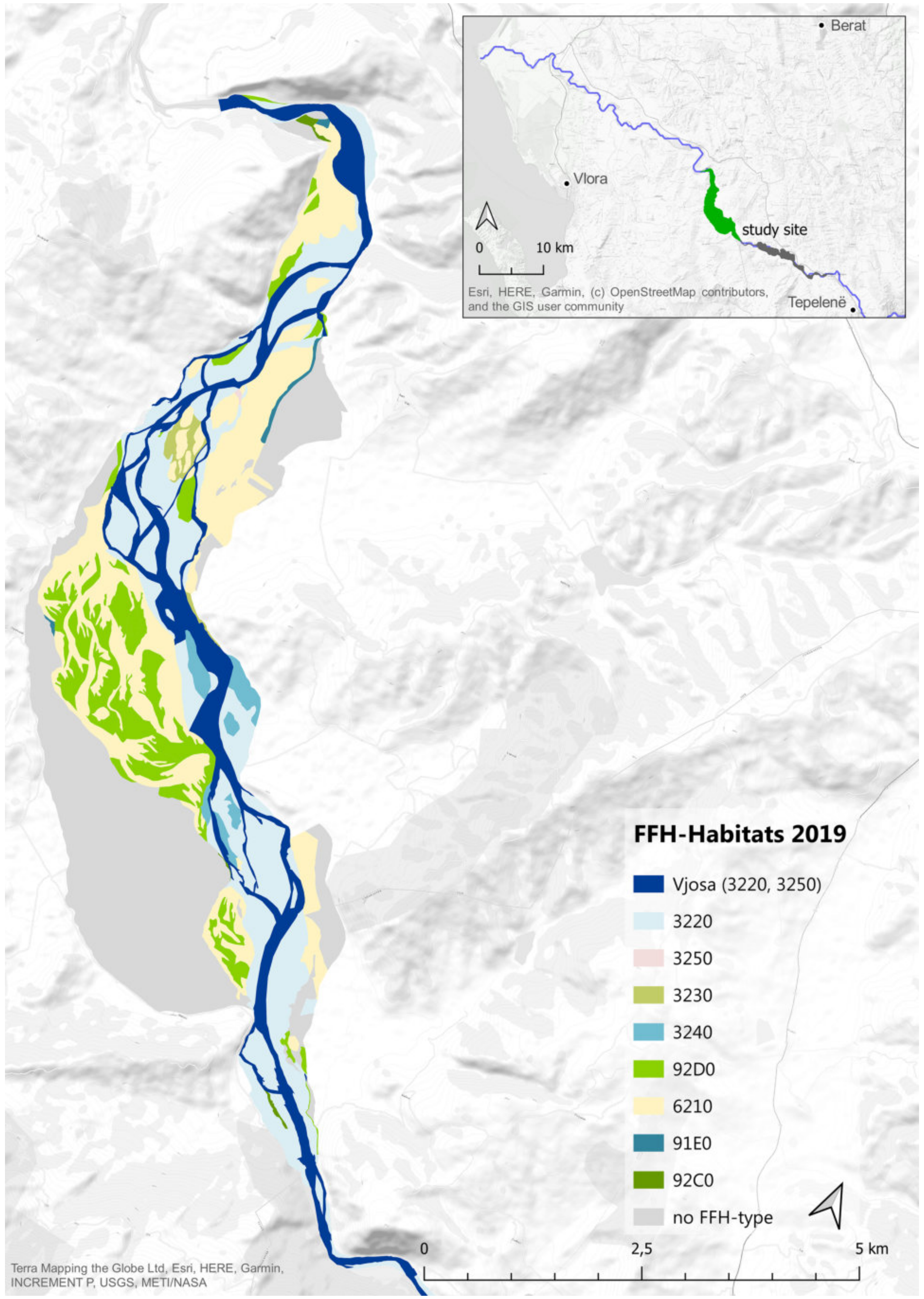


Figure 15: Map of the natural habitat types listed in the Habitat Directive; Part 1 from 2019 with the extended investigation area, upstream of Poçem (modified from Randl (in prep.)).

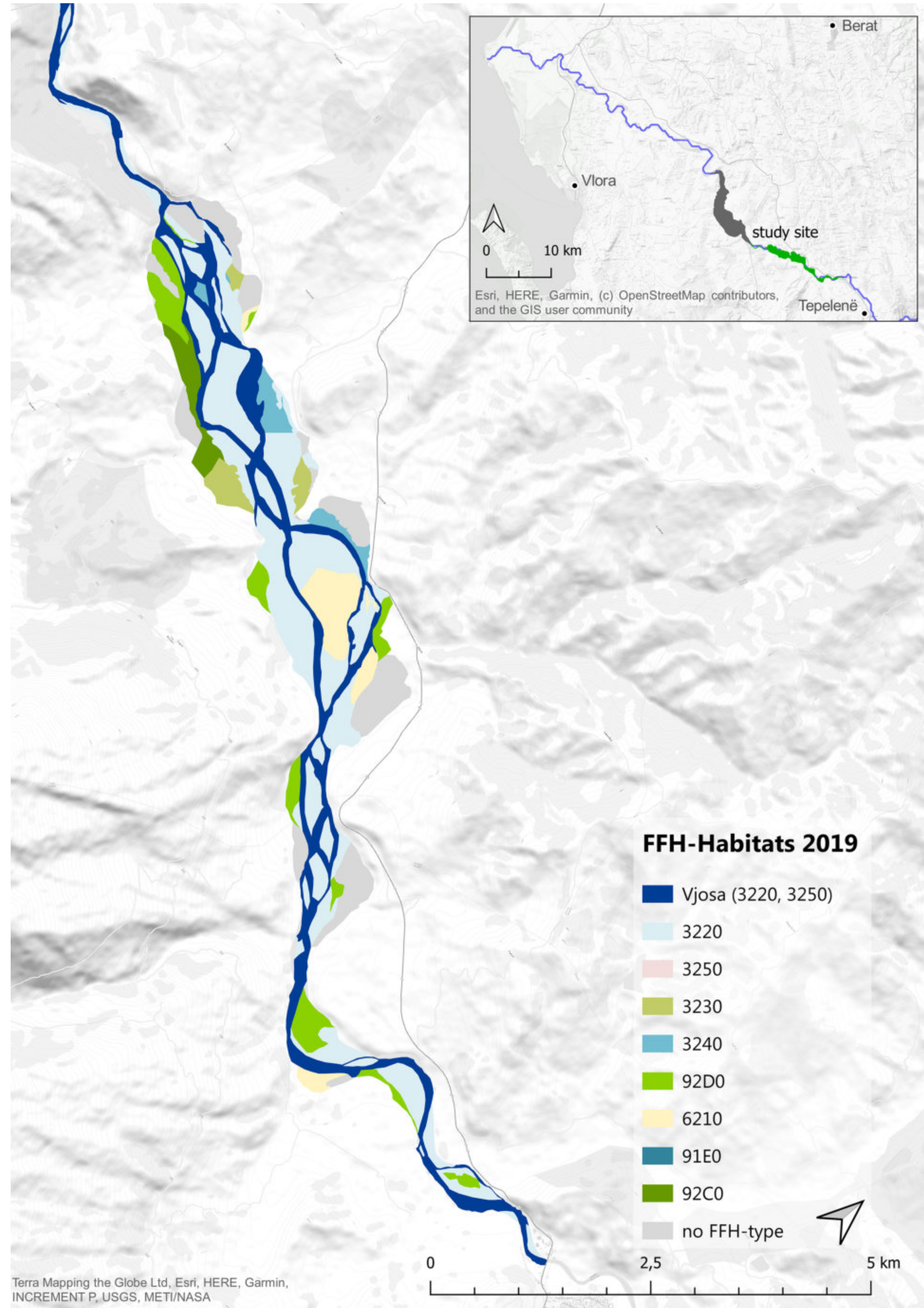


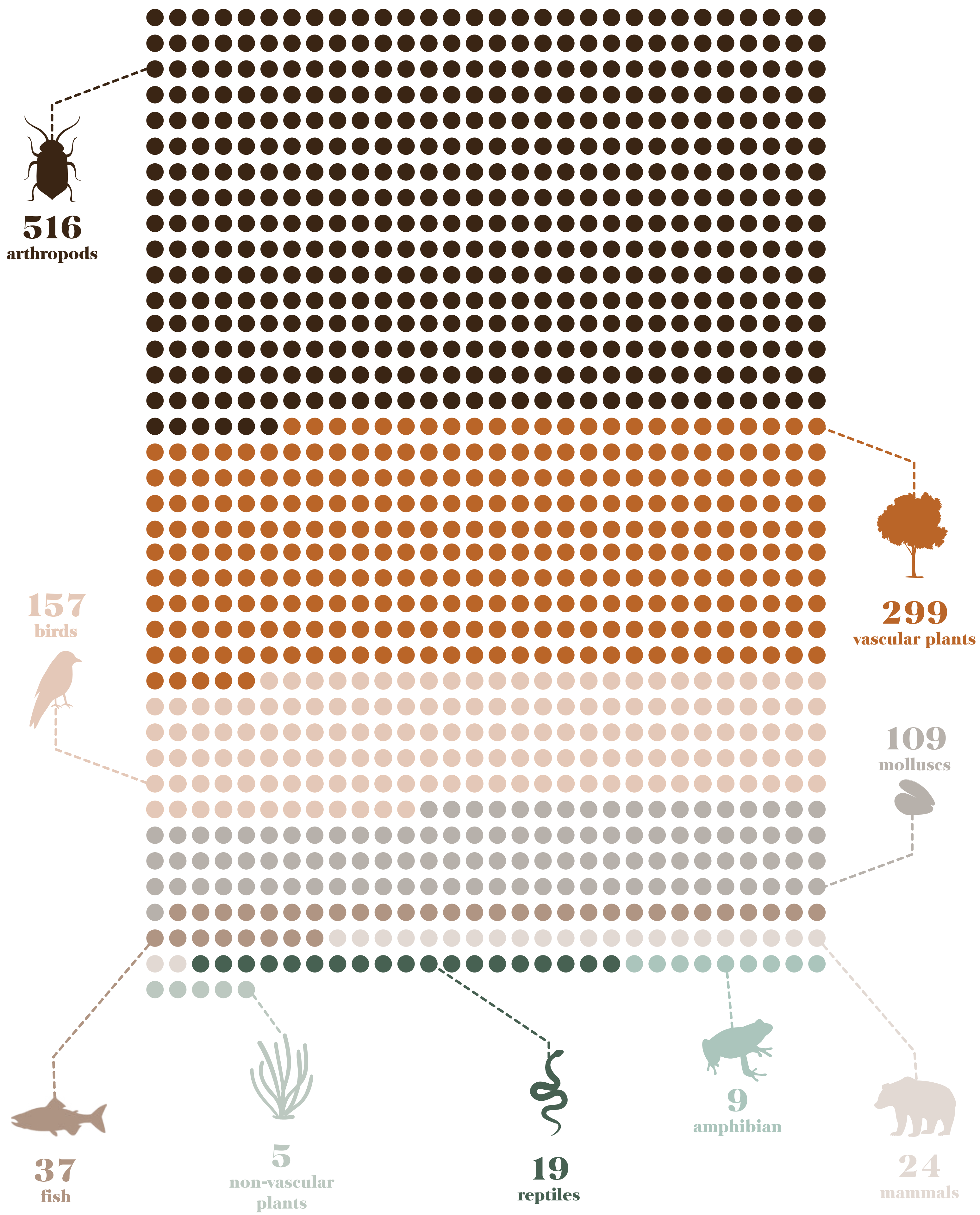
Figure 16: Map of the natural habitat types listed in the Habitat Directive; Part 2 from 2019 with the extended investigation area, upstream of Kalivaç (modified from Randl (in prep.)).

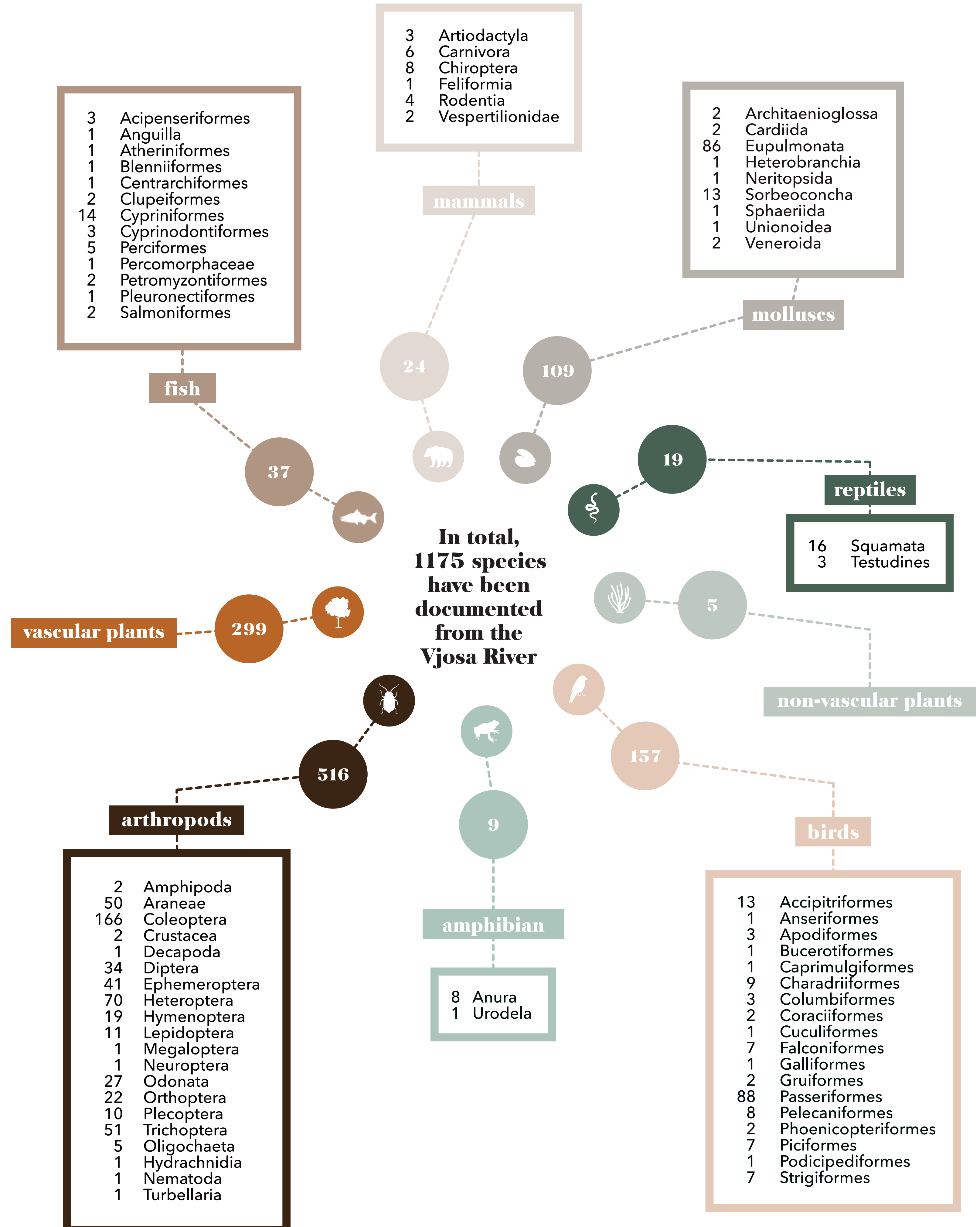
Overall biodiversity

and species conservations status

PHOTO: **STEFAN SCHMUTZ**

In the following chapter the documentation of organisms in the Vjosa is based on the species lists in Schiemer et al. (2018), Egger et al. (2019), and Fontes et al. (2019) and are analysed, regarding their conservation status, according to national and international laws and guidelines.


516
arthropods
299
vascular plants
157
birds
109
molluscs
37
fish
5
non-vascular
plants
19
reptiles
9
amphibian
24
mammals


In total,
1175 species
have been
documented
from the
Vjosa River
mammals
24
3 Artiodactyla
6 Carnivora
8 Chiroptera
1 Feliformia
4 Rodentia
2 Vespertilionidae
fish
37
3 Acipenseriformes
1 Anguilla
1 Atheriniformes
1 Blenniiformes
1 Centrarchiformes
2 Clupeiformes
14 Cypriniformes
3 Cyprinodontiformes
5 Perciformes
1 Percomorphaceae
2 Petromyzontiformes
1 Pleuronectiformes
2 Salmoniformes
molluscs
109
2 Architaenioglossa
2 Cardiida
86 Eupulmonata
1 Heterobranchia
1 Neritopsida
13 Sorbeoconcha
1 Sphaeriida
1 Unionoidea
2 Veneroida
reptiles
19
16 Squamata
3 Testudines
vascular plants
299
non-vascular plants
5
arthropods
516
2 Amphipoda
50 Araneae
166 Coleoptera
2 Crustacea
1 Decapoda
34 Diptera
41 Ephemeroptera
70 Heteroptera
19 Hymenoptera
11 Lepidoptera
1 Megaloptera
1 Neuroptera
27 Odonata
22 Orthoptera
10 Plecoptera
51 Trichoptera
5 Oligochaeta
1 Hydrachnidia
1 Nematoda
1 Turbellaria
amphibian
9
8 Anura
1 Urodela
birds
157
13 Accipitriformes
1 Anseriformes
3 Apodiformes
1 Bucerotiformes
1 Caprimulgiformes
9 Charadriiformes
3 Columbiformes
2 Coraciiformes
1 Cuculiformes
7 Falconiformes
1 Galliformes
2 Gruiformes
88 Passeriformes
8 Pelecaniformes
2 Phoenicopteriformes
7 Piciformes
1 Podicipediformes
7 Strigiformes

CONSERVATION STATUS

PHOTOS: **GERNOT KUNZ**

ALL 1175 DOCUMENTED SPECIES

were checked for their status according to: 1) the IUCN, 2) the Albanian Red List 3) the Bern Convention, 4) the Birds Directive, and 5) the Habitats Directive. --»

OF THEM, 39 SPECIES

are listed by the IUCN and 119 are on the Albanian Red List, while 15 of the IUCN-listed and 74 of the Albanian red-listed species are classified in threatened categories (CR, EN, VU) (Table 7). --»

A TOTAL OF 148 OF THE SPECIES

are listed in Annex 1–3 of the Bern Convention, 41 in the Birds Directive, and 78 in the Habitat Directive (Table 8). A summary and description of the legal texts and definitions can be found in Chapter "Legal Framework and Evaluation/Assessment Criteria".

Table 7. Total number of species and number listed in threatened categories by the IUCN and the Albanian Red List.

	Listed	Listed in threatened categories (CR, EN, VU)
IUCN	39	15
Albanian Red List	119	74

Table 8. Number of species listed in annexes of the Bern Convention, Birds Directive, and Habitat Directive.

	Total listed	Ann. I	Ann. II	Ann. III	Ann. IV	Ann. V
Bern Convention	148	1	138	9		
Birds Directive	41	36	5			
Habitat Directive	78		38		34	6

Table 9–Table 13 indicate the numbers of species in each taxonomic group and their threat category or affiliation to the different annexes of the IUCN, Albanian Red List, Bern Convention, Birds Directive, and Habitat Directive.

Table 9. Number of species listed by the IUCN for each taxonomic group and category (CR = critically endangered; EN = endangered, VU = vulnerable, NT = near threatened, LC = least concern, DD = data deficient).

IUCN	**CR**	**EN**	**VU**	**NT**	**LC**	**DD**	**Total**
Amphibians		1					1
Arthropods				3			3
Birds		1	1	4			6
Fish	4	2	1	2			9
Mammals			1	3			4
Molluscs		1	1	2		1	5
Reptiles				3	1		4
Vascular plants			2	1		4	7
Total	**4**	**5**	**6**	**18**	**1**	**5**	**39**

Table 10. Number of species listed in the Albanian Red List for each taxonomic group and category (CR = critically endangered; EN = endangered, VU = vulnerable, NT = near threatened, LC = least concern, DD = data deficient, NE = not evaluated)

	CR	**EN**	**VU**	**LR**	**DD**	**NE**	**Total**
Amphibians				5			5
Arthropods			5	2			7
Birds	6	6	18	10	3		43
Fish		5	1	2			8
Mammals		2	4	10	2		18
Molluscs				1			1
Reptiles	3			7		2	12
Vascular plants	8	5	11	1			25
Total	**17**	**18**	**39**	**38**	**5**	**2**	**119**

Table 11. Number of species listed in the Bern Convention for each taxonomic group and their relevant Annex

Bern Convention			
	Ann. I	Ann. II	Ann. III
Amphibians		2	
Arthropods		4	
Birds		106	
Fish		4	6
Mammals		12	3
Reptiles		10	
Vascular plants	1		
Total		138	

Table 12. Number of species listed in each Annex of the Birds Directive

	Ann. I	Ann. 2
Birds	36	5

Table 13. Number of species listed in the Habitat Directive for each taxonomic group and their relevant Annex

	Ann. II	Ann. II Priority	Ann. IV	Ann. V	Total
Amphibians	1		3	1	5
Arthropods	3		4		7
Fish	12	2	2	4	20
Mammals	10	2	13	1	26
Molluscs	3		1		4
Reptiles	5		10		15
Vascular plants			1		1
Total	**34**	**4**	**34**	**6**	**78**

IMPACT OF KALIVAÇ HPP

Several studies have been conducted to estimate the potential environmental impact of the proposed Kalivaç HPP (Egger et al. 2019; Fontes et al. 2019; Schiemer et al. 2020; Schiemer et al. 2018). The aim in this chapter is to summarise these findings and to add additional perspectives.

Sediment transport and morphodynamics

PHOTO: **GERNOT KUNZ**

In a detailed study, Hauer et al. (2019) investigated sediment transport and morphodynamics in the Vjosa River and highlighted several economic and ecological constraints. In the following pages a summary of the work and their conclusions is presented.

1

The filling up of Vjosa reservoirs with sediment is calculated to occur within 30–40 years for Poçem and 45–60 years for Kalivaç

Owing to the high sediment transport rates of the Vjosa, an annual reservoir loss of about 2% in the case of Kalivaç and › 2% in the case of Poçem is forecasted (Figure 18). These numbers are more than twice as high as global average annual storages losses (0.87% per year). Owing to the lack of sediment transport data for discharges above 1000 $m^3 s^{-1}$, there are some uncertainties concerning these predictions. However, it is expected that additional data on extremely high discharges will increase these forecasted annual deposition rates.

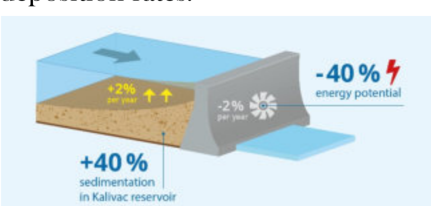


Figure 18. More sediment, less energy: The Kalivaç reservoir would constantly fill up with sediment, leading to a 2% loss of energy potential each year. After 20 years, the power plant would lack 40% of its original capacity.

2

High economic cost are expected for sediment management and treatment

The numerical modelling of the planed reservoir in Kalivaç clearly showed that frequent (annual) flood events in the range of ›1000 $m^3 s^{-1}$ would create currents in the reservoir, which would transport the suspended load through the reservoir with various stages of deposition in the impounded sections. Those currents, induced by frequent flooding, wouldl (with a high certainty) cause severe problems at (i) the bottom outlet and (ii) the intakes to the turbines, owing to deposition. To overcome these issues, costly dredging would be necessary from the first year of operation.

3

Riverbed incision (Figure 19) will be the consequence if the sediment transported by the Vjosa is trapped in hydropower reservoirs

This incision would result in (i) changes in downstream groundwater levels (problems for agricultural land use and floodplain vegetation), (ii) a risk of uncontrolled channel avulsion in the event of floods (loss of agricultural land and ecological degradation in the long-term).

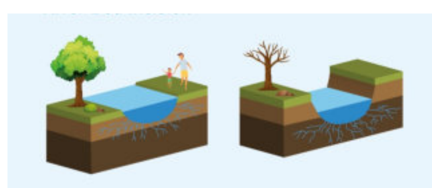


Figure 19. Owing to the lack of sediment downstream of the dam, the Vjosa riverbed would erode deeper and deeper into the ground, also lowering the ground water level so that trees could no longer reach the water.

4

Coastal (Lagoon) erosion will increase owing to a lack of sediment transport

The interruption of the sediment continuum would have severe consequences for the coastline in this part of Albania. As previous studies have already shown, the erosion of the coastline is already in progress and will accelerate drastically if dams hold back the sediment in the Vjosa. This erosion is of high socioeconomic relevance to the Albanian state and poses a high risk for infrastructure in the event of Adriatic storms (compare this to Hurricane–coastline experiences in the US).

5

Degradation of ecology and loss of European sea-side tourism as well as of eco-tourism in the Vjosa catchment must be expected

This has not been directly assessed in the present study; however, the expected severe degradation in the Vjosa catchment as a result of all four points mentioned above will inevitably lead to socioeconomic consequences related to tourism for the coastal part of Albania, as well as to a loss of potential for eco-tourism along the Vjosa. Infrastructure projects along the coastline will be at risk and marine resources related to the lagoon will disappear.

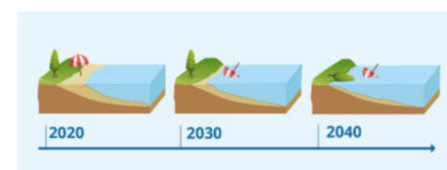


Figure 20. The Kalivaç dam would lead to enormous coastal erosion, as it would block 5 million tonnes of sediment. Ecosystems, including the Narta lagoon, as well as potential tourism would be at risk.

Σ

In summary, there is the risk of a 'lose-lose-lose situation'

Based on (1) and (2) it can be concluded that the construction of dams (reservoirs) in this specific river and particularly in this section of the river system (huge catchment area and high sediment loads) is a problematic concept in terms of energy generation and profitability. Dams (reservoirs) are created to capture rainfall and runoff on a daily, weekly, or annual basis. In addition to high annual losses in storage volume, the frequent overspill of flooding will cause severe operational problems. Since the interactions between in-stream hydraulics, sediment transport, river morphology, and ecology are not adequately understood (from a process perspective), implementation of sustainable sediment mitigation measures in river management plans are missing. Furthermore, there is a lack of standardised evaluation methods for detecting disturbances in sediment regimes. In summary, there is the risk of a 'lose-lose-lose situation':

Loss 1: High economic costs owing to sediment-related problems in the reservoir.

Loss 2: Ecological degradation of a large unique river system in Europe.

Loss 3: Long-term negative impacts on the coastline and tourism in this part of Albania.

IMPACTS ON

HABITAT-DIRECTIVE HABITATS

Figure 21 shows the Habitat-Directive habitats in the affected area of the planned Kalivaç HPP. Seven different types are shown (with a total coverage of 61% within the 110 m a.s.l. contour line). The red line indicates the contour line at the height of the dam (110 m a.s.l.); after construction a total of 1024 ha of morphological floodplain will be flooded.

The highest percentage (27%) is type 3250 (Constantly flowing Mediterranean rivers with *Glaucium flavum*). Type 3220 (Alpine rivers and the herbaceous vegetation along their banks) covers 12% and is, together with types 92C0 (*Platanus orientalis* and Liquidambar orientalis woods, 8%) and 6210 (Semi-natural dry grasslands and scrubland facies on calcareous substrates, 6%), in the middle of the range. Each of the three remaining types covers almost 3% and they are all located in the western part of the affected area. Only 14% (147 ha) of the floodplain zone is not designated as any habitat mentioned in the Habitat Directive (Table 14).

The majority of vegetation types that would be flooded by the HPP, and thus destroyed, are assigned to a habitat of the Habitat Directive. The vegetation types lost downstream of the dam in the short- to medium-term are also predominantly habitats mentioned in the Habitat Directive and will be irretrievably lost. The older floodplain forest stages that would develop in their place can also be classified as Habitat-Directive types (91E0, softwood floodplain forests; 91F0, hardwood floodplain forests; 92C0, plane tree floodplain forests), but they are not subject to a natural disturbance regime and, in the long-term, will transform into terrestrial habitats that are not typical of floodplain forests. All in all, the construction of the HPP would have an enormous negative impact on many habitats listed in the Habitat Directive (Table 15).

In summary, **877 ha** of habitats listed in the Habitat Directive will be **directly lost** in the reservoir area. Furthermore, at least **2854 ha** Habitat-Directive habitats **will be directly affected downstream** by morphodynamic changes and the long-term loss of these habitats would be expected.

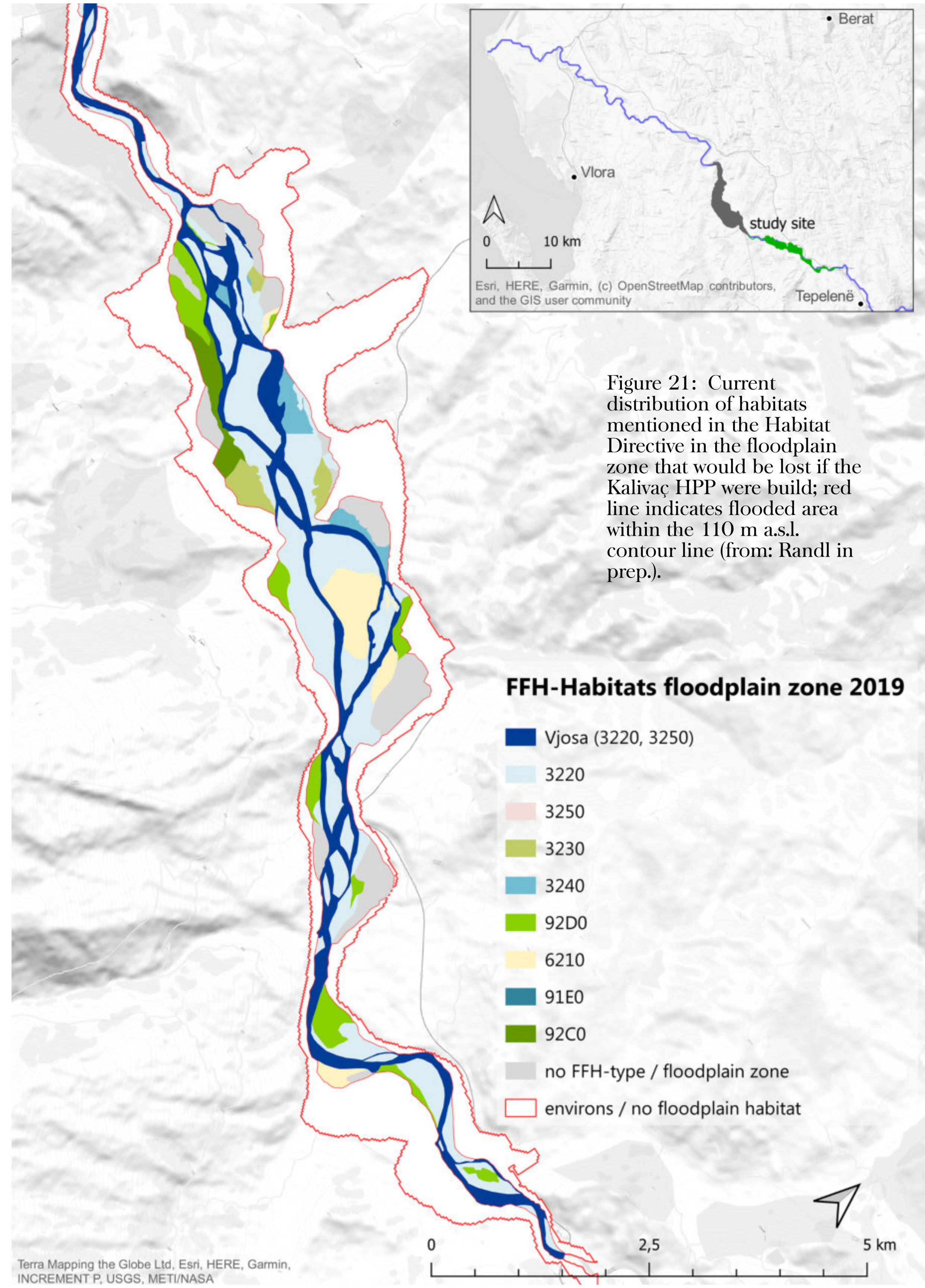


Figure 21: Current distribution of habitats mentioned in the Habitat Directive in the floodplain zone that would be lost if the Kalivaç HPP were build; red line indicates flooded area within the 110 m a.s.l. contour line (from: Randl in prep.).

Table 14. Area (ha) of impacted Habitat-Directive types

(3220, 3250, 3230, and 3240) for three different sections: Planned Kalivaç reservoir, downstream of Kalivaç Dam to Poçem bridge, and downstream of Poçem bridge; * = Only total area of Habitat-Directive habitats was evaluated

Habitat type	Description	Upstream of Kalivaç Dam (reservoir) (ha)	Downstream of Kalivaç Dam to Poçem bridge (ha)	Downstream of Poçem bridge (ha)
3220	Alpine rivers and the herbaceous vegetation along their banks	118	98	*
3250	Constantly flowing Mediterranean rivers with *Glaucium flavum*	276	368	*
3230	Alpine rivers and their ligneous vegetation with *Myricaria germanica*	30	14	*
3240	Alpine rivers and their ligneous vegetation with *Salix eleagnos*	28	38	*
	Total	**704**	**795**	**1 386***

Table 15. Area (ha) of impacted Habitat-Directive types

(92D0, 6210, 91E0, and 92C0) for three different sections: Planned Kalivaç Reservoir, downstream of Kalivaç Dam to Poçem bridge, and downstream of Poçem bridge (ha)

Habitat type	Description	Upstream of Kalivaç Dam (reservoir) (ha)	Downstream of Kalivaç Dam to Poçem bridge (ha)	Downstream of Poçem bridge (ha)
92D0	Southern riparian galleries and thickets (Nerio-Tamaricetea and Securinegion tinctoriae)	81	197	Not evaluated
6210	Semi-natural dry grasslands and scrubland facies on calcareous substrates	63	464	Not evaluated
91E0	Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (Alno-Padion. Alnion incanae. Salicion albae)	0	8	Not evaluated
92C0	Platanus orientalis and *Liquidambar orientalis* woods (*Platanion orientalis*)	29	5	Not evaluated
	Total	**173**	**673**	**-**

PHOTO: **STEFAN SCHMUTZ**

I

Impacts on flora and riparian vegetation

The most important effect is the direct loss of floodplain vegetation as a result of damming. This loss is irreversible and cannot be compensated for by mitigation measures. The proposed 'new wetlands and riparian vegetative communities' (ABKONS 2019a) along the new shoreline (littoral zone) will not be able to establish because of hydropeaking. The constantly and rapidly changing water level prevents the emergence of vegetation – neither typical hygrophytes nor terrestrial species are adapted to these extremely changeable conditions. This zone will therefore be largely vegetation-free.

The second important impact on the river and floodplain ecosystem concerns the river section downstream of the dam. Owing to the lack of sediment and as a consequence of reduced hydromorphodynamics, the progression of the vegetation will increase, and the riverbed will become overgrown with vegetation. Specifically, the proportions of young succession phase habitats (like gravel bars and pioneer vegetation) and pioneer-shrub type habitats will diminish in the short- to mid-term.

In total, the construction of the HPP would lead to a drastic loss of typical floodplain habitat and vegetation, and thus to a drastic decline in biodiversity. It can be assumed that these negative effects fully extend downstream at least to the confluence of the Shushicë or Vlora Rivers and in reduced form to the estuary delta.

The floodplain flora of gravel-bed rivers is not only threatened by building operations and the flooding of the area behind the dam. Experience from gravel-bed rivers in the Alps show very drastic long-term effects of damming: the interrupted sediment transport, the loss of adequate substrata, and the loss of repeatedly created gravel/sand banks and islands. Several of the pioneer species of floodplains are strongly adapted to these dynamic processes. Species like Typha minima and Tamarix parviflora are dependent on these patch dynamics. They would lose their habitats and large parts of their distribution areas, and over time, would likely become extinct.

The changed ecological conditions downstream of the dam, including progressive incising because of the lack of sediment, would not only change the soil hydrology but equalise the site conditions and reduce the great variety of habitats in the transversal and longitudinal sections of the river. Consequently, specific habitats will be lost, e.g., slowly flowing side arms with vegetation of the class Isoëto-Nanojuncetea with uncompetitive species like Fimbristylis bisumbellata and the small Cyperus species *C. fuscus* and *C. flavescens*.

One of the least considered facts is the huge impact on the wetland complex of the Vjosa Delta–Narta lagoon. Because of the suppressed sediment transport, the erosion processes in the delta would be drastically increased. Consequently, the Important Bird Area in the southern part of the Vjosa Delta will be strongly affected. Bego et al. (2019) show the morphological and vegetation changes that occurred in the Buna Delta after construction of an HPP upstream in the Drin River.

I

Impacts on fish

Longitudinal connectivity is regarded as the most important connectivity dimension for freshwater fish species, because it allows upstream and downstream fish migration cycles to occur (Baras and Lucas 2001). Weirs and dams interrupt longitudinal connectivity, promote species isolation, and prevent fish movement for reproduction, feeding, and habitat colonisation purposes, inducing potential genetic impoverishment (Faulks et al. 2011; Gehrke et al. 2002). Furthermore, they promote the spread of alien fish species. Even small obstacles can have a significant effect on flow, temperature regime, animal movement and habitat quality (Larinier 2001).

The planned Kalivaç dam would create a reservoir with an area of 18.3 km² and a total length of 14.5 km (Hauer et al. 2019). Within this reservoir about 2.3 million m² of riverine aquatic habitats would be lost and turned into a lacustrine environment. The construction of reservoirs changes river systems ecologically by disrupting the connection between the river and the lateral backwaters, by changing the shoreline, and by stabilising previously dynamic water levels, among other impacts (Schiemer and Waidbacher 1992; Waidbacher et al. 2018). These reservoirs neither provide riverine (reduced flow, increased depth, silty to muddy sediment resulting from increased sedimentation) nor lacustrine conditions (low average annual temperature of the river, the lack of shoreline structures, no stratification, short retention times, and low plankton density).

Overall, more than **2.9 million individuals**, or roughly **25 metric tonnes** of fish are calculated to currently inhabit this area, with more than 50% of the species having an IUCN threat level of 'Near threatened' (NT) or higher. As the majority of the present fish species are rheophilic and show migratory behaviour, it can be presumed that the reservoir would have severe impacts, up to and including a complete loss of these species.

The major impact **upstream** is the complete blockage of migratory fish species. Out of the 1109 km river network length, 1062 km are currently accessible. After construction of the proposed dam at Kalivaç, **881 km of the river would no longer be reachable** for fish and only 228 km would remain (Figure 22).

For species with an ecological obligation to undertake reproductive migrations, the maintenance of longitudinal connectivity in riverine systems is reported to be of paramount importance (Jungwirth et al. 1998; Lasne et al. 2007), especially for long-distance migratory species that migrate between marine and freshwater environments.

The high proportions of anadromous, catadromous, and diadromous fish highlight the necessity of functional connectivity from the sea to the upstream sections of the river and back. In total **13 species would completely disappear**, including several threatened species, such as the European sea sturgeon (*Acipenser sturio*), Adriatic Sturgeon (*Acipenser naccarii*), and European eel (*Anguilla anguilla*). The latter has been reported to occur in the entire Vjosa/Aoos River and its tributaries, both in Albania and in Greece. Furthermore, longitudinal connectivity is also crucial for all other riverine fish species as they all migrate to a certain extent. Dispersal is crucial for population persistence as it contributes substantially to ecological, behavioural, and evolutionary processes (Jungwirth et al. 1998; Lasne et al. 2007; McMahon and Matter 2006).

In principle, fish bypasses have the potential to mitigate this upstream blockage to a certain extent. Based on the literature (e.g., BMLFUW 2012, FAO 2002), the most important challenges include **ensuring findability** (optimal positioning of the entrance in relation to the transverse structure, sufficient discharge in relation to the river size, sufficient flow velocity of the current leaving the fish bypass, and bottom connection), **guaranteeing passability** (bypass dimensions, sufficient basin dimensions, turbulence, suitable shaping of pool transitions, roughness and bottom connection, height differences between the pools, permissible flow velocities and gradients, rough sole characteristics), and checking the **passability of the bypass exit** (fluctuating upper and lower water levels, suitable location, bottom connection, Protection of the bypasses entrance and exit against bed load and alluvial deposits). These factors are of essential relevance for the construction and operation of bypasses. Furthermore, fish bypasses need to be designed according to the swimming performance, behaviour, and size of the fish to facilitate migration. Body dimensions, known behaviour (e.g., migration in larger groups, avoidance of openings that are too small), and preferences (habitat, current) serve as the basis for defining the dimensions and design.

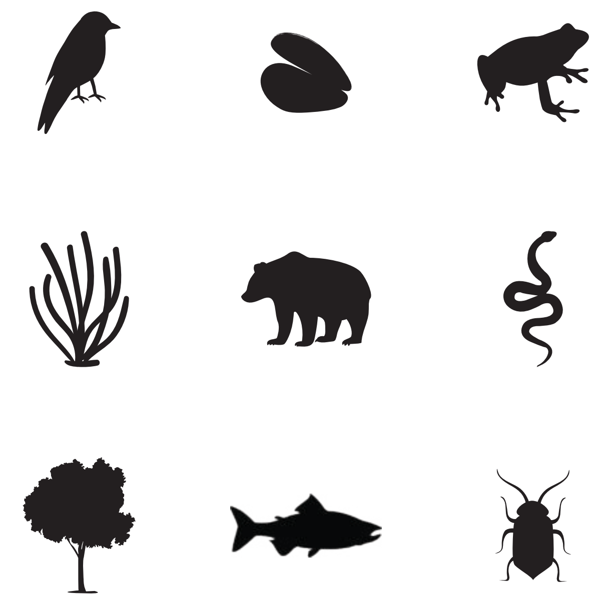
In the present case of the Kalivaç HPP, with a height difference of 37 m between the head- and tail waters, and its location in a canyon, the most suitable bypass type is a technical fish bypass such as a vertical slot bypass. They have hardly any near-natural habitat elements, and therefore only ensure continuity. Vertical slot passes have comparatively higher construction costs and high maintenance costs. According to the Austrian Guidelines for the construction of fish bypasses (BMLFUW 2012), a maximum water level difference between the basins of 13 cm and a minimum basin length of 250 cm must be adhered to. This produces a total number of 285 basins with a total length of more than 700 m. Alternately, according to the guidelines of the FAO (FAO 2002), which consider graylings, chubs, breams, and other species, a maximum water level difference between the basins of 20 cm and a minimum basin length of 140–200 cm would be necessary, resulting in a total length of only 260–370 m. If sturgeons are considered, the total length increases to 925 m. Planning and constructing such a long migration facility, however, entails major challenges and costs. It would be one of the longest bypasses worldwide and therefore limited experience is available regarding its functionality.

As mentioned above, all species migrate within their lifecycle to a certain extent. **Downstream** migration is as important as upstream migration, but is often neglected. The European eel, especially, is very sensitive in this regard (MacNamara and McCarthy 2014). Additionally, changes in thermal regimes below dams have been implicated in the extirpation of stenothermal species (Edwards 1978; Vanicek 1970). the reproduction for most fish species take place on gravel substrate. Thus, hydrological disturbances and dynamic floods are necessary as they prevent the interstitial spaces of the sediment from clogging, enhancing the habitat not only for fish and egg development, but also for other organisms such as macroinvertebrates (Dole-Olivier 2011; Dudgeon et al. 2006).

Figure 22.
Vjosa River network; red river stretches will be cut off from all migratory fish species in the event of construction

OVERALL ASSESSMENT OF IMPACT ON BIOTA

PHOTO: **YUCCA FILMS**



Out of 1175 species, 865 were evaluated by scientific experts regarding the impact of the Kalivaç HPP (in the proposed reservoir area, and downstream and upstream of it) on their populations (Figure24). The evaluated species included 340 arthropods, 299 vascular plants, 109 molluscs, 36 fish, 24 birds, 24 mammals, 19 reptiles, 9 amphibians, and 5 non-vascular plants.

Within this risk assessment, impacts on species were classified into six categories (inestimable, low or insignificant, moderate reduction, severe reduction, high risk of local extinction, and total local default). The reservoir stands out as the most severely affected area with a total local default of around 40% of all species. However, the river stretches downstream and upstream (including tributaries) also exhibit marked impacts from the HPP.

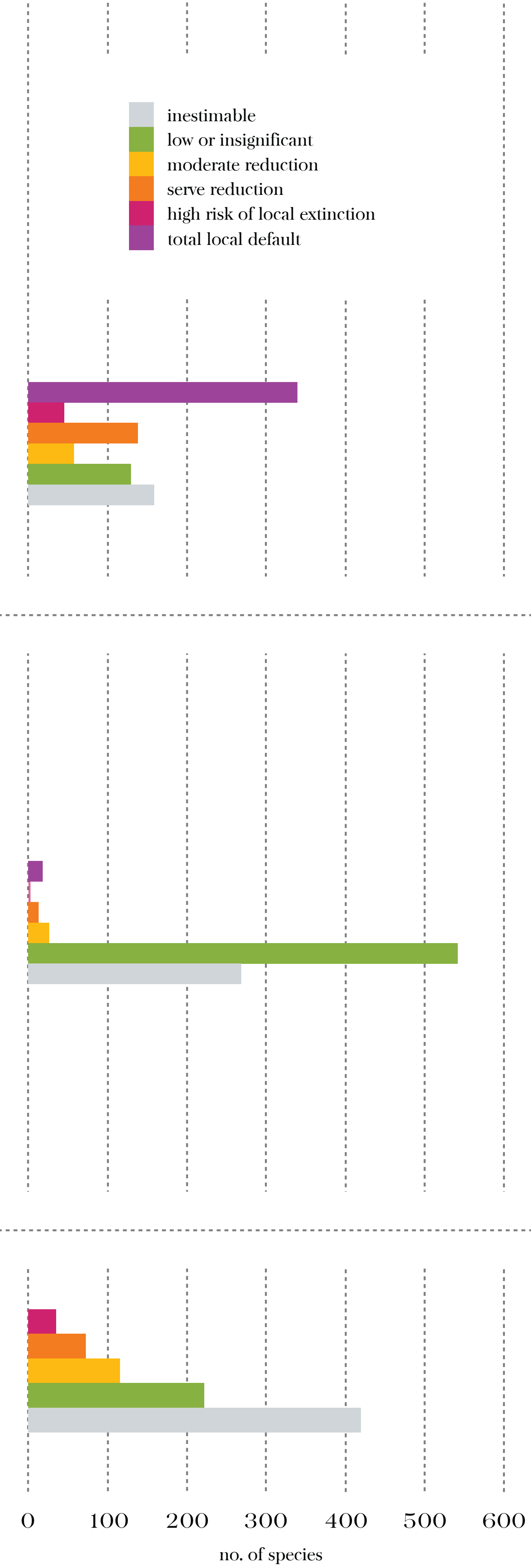


Figure 24. Impact assessment on the populations of 865 evaluated species.

RESERVOIR

Within the 18.3 km² reservoir, 338 species will exhibit a total local default, 174 will have a high risk of local extinction or be severely reduced, and 186 are expected to react with a low to moderate reduction. Table 16 gives a detailed overview of the evaluation of the different species groups. Within the evaluated species there are several threatened and protected species that would be affected to different extents. As illustrated in Figure 25, a certain number of species listed in Annex 2 of the Bern Convention (33), the Albanian Red List (50), Annex 2 of the Fauna Habitat Directive (14), and by the IUCN (15) will be adversely affected.

UPSTREAM

The major impact upstream is the complete blockage of aquatic migratory species. Out of the 1109 km of permanent river network length, 1062 km are currently accessible. After construction of the proposed dam at Kalivaç, 881 km will no longer be reachable and only 228 km will remain reachable from the sea and the downstream river sections (Figure 22). Consequently, 17 fish species will exhibit a total default, while 27 species will be either severely or moderately reduced. Table 17 gives a detailed overview of the evaluation for each of the different species groups. Within the evaluated species, several threatened and protected species would be affected to different extents (Figure 26). The species that would exhibit total default and are listed in one of the considered lists are all fish. In total, the numbers of species listed in Annex 2 of the Bern Convention (2), the Albanian Red List (8), Annex 2 of the Fauna Habitat Directive (5), and by the IUCN (6) that will be adversely affected are much smaller than in the reservoir area. However, the affected river length of 881 km also includes several tributaries such as the Langarica, Drinos, Benje, Sarantaporos, and Voidomatis and the Greek part of the Vjosa River (Aoos). Diadromous fish species such as the European eel will be completely lost in these stretches (for more details see chapter "Impacts on Fish").

DOWNSTREAM

Although often ignored, the downstream effects of HPPs pose equal or even greater threats to aquatic and semiaquatic species than upstream effects. In the present case, approx. 110 km will be affected, mainly by changes in the discharge and sediment regimes. The long-term effects can be especially dramatic for fauna and flora (see also chapter "Downstream effects" and "Sediment transport and morphodynamics"), and cannot be clearly assessed. A total of 108 species will exhibit severe reduction or even face a high risk of local extinction, while 337 are expected to react with low to moderate reductions. For a conspicuous number of 420 species, the impacts were evaluated as being inestimable (Table 18). Still, 12 species listed by the IUCN, four in Annex 2 of the Bern Convention, 15 on the Albanian Red List, and 16 in Annex 2 of the Fauna Habitat Directive will be negatively impacted (Figure 27).

RESERVOIR

Table 16.
Degree of impact on species groups within the reservoir area.

	inestimable	low or insignificant	moderate reduction	serve reduction	high risk of local extinction	total local default	
Birds				22	2		**24**
Amphibians	4			3	2		**9**
Reptiles				4	15		**19**
Mammals	16	8					**24**
Fish	5	5	4	5		17	**36**
Molluscs	38	29	23	19			**109**
Arthropods	92	75	29	44	26	74	**340**
Vascular plants	4	12	1	40		242	**299**
Non-vascular plants						5	**5**
∑ **Total**	**159**	**129**	**57**	**137**	**45**	**338**	**865**
					520		

UPSTREAM

Table 17.
Degree of impact on species groups within the upstream river sections.

	inestimable	low or insignificant	moderate reduction	serve reduction	high risk of local extinction	total local default	
Birds	24						**24**
Amphibians	9						**9**
Reptiles	19						**19**
Mammals	20	4					**24**
Fish	3	16				17	**36**
Molluscs	37	65	3	4			**109**
Arthropods	101	223	12	4			**340**
Vascular plants	57	228	10	4			**299**
Non-vascular plants		5					**5**
∑ **Total**	**270**	**541**	**25**	**12**		**17**	**865**
					29		

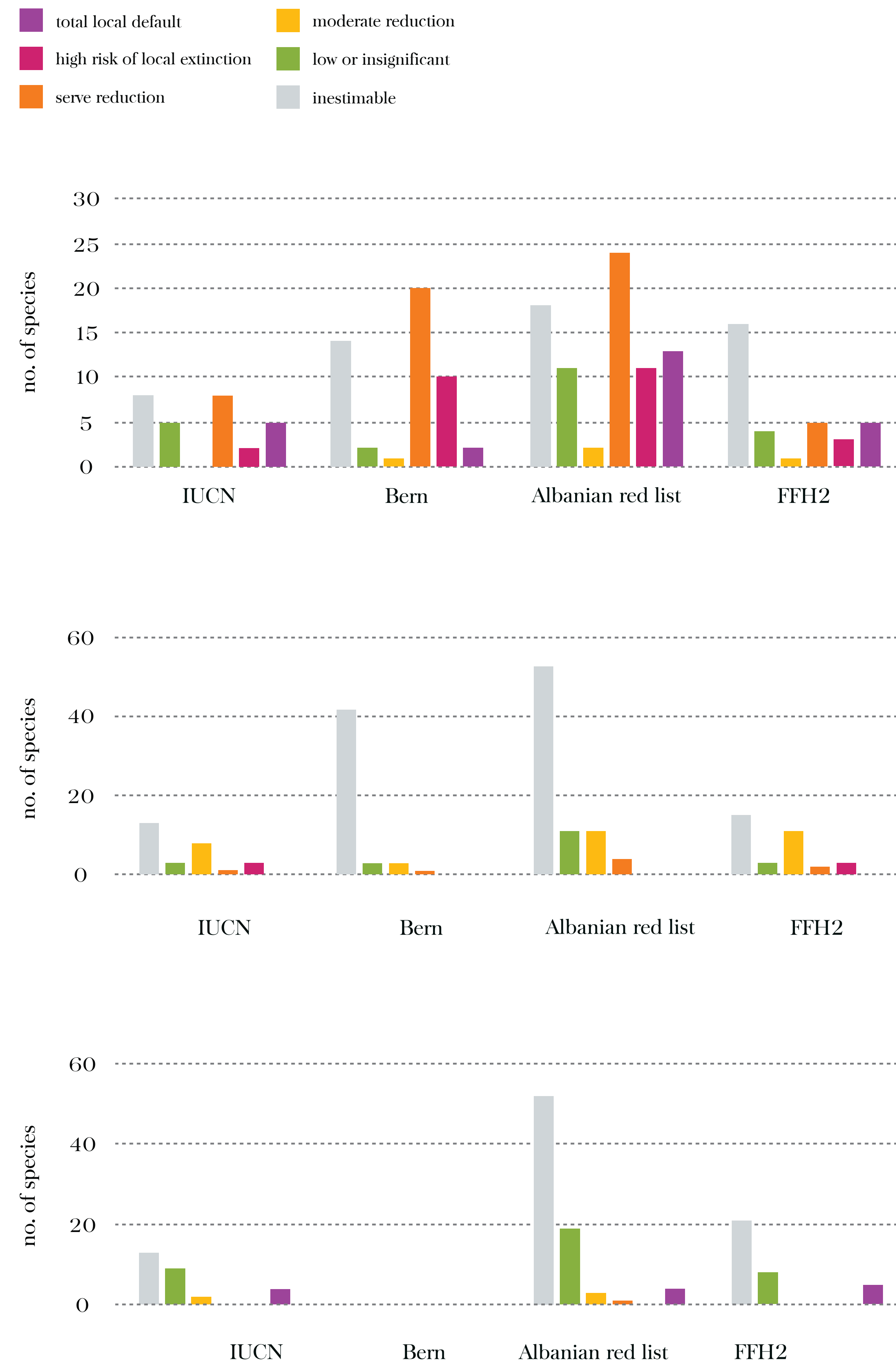
DOWNSTREAM

Table 18.
Degree of impact on species groups within the downstream river sections.

	inestimable	low or insignificant	moderate reduction	serve reduction	high risk of local extinction	total local default	
Birds	24						**24**
Amphibians	5		2	1	1		**9**
Reptiles	17			2			**19**
Mammals	20	2	2				**24**
Fish	4	14	18				**36**
Molluscs	39	17	23	26	4		**109**
Arthropods	117	136	26	33	28		**340**
Vascular plants	189	52	45	11	2		**299**
Non-vascular plants	5						**5**
∑ **Total**	**420**	**221**	**116**	**73**	**35**		**865**
				108			

inestimable
low or insignificant
moderate reduction
serve reduction
high risk of local extinction
total local default

Figure 25, 26 & 27.
Impact assessment on the populations within the reservoir, upstream & downstream sections for species listed on the IUCN Red List, Bern Convention, Albanian Red List, and Annex 2 of the Fauna and Flora Habitat Directive.



Legal Considerations for the proposed project

The studies on the flora and fauna conducted to date in the area of interest and the documentation of the results in this report show clearly the extraordinarily high value of the Vjosa and its floodplain for biodiversity and nature conservation purposes. Additionally, in chapter "Reference for Europe" with reference to Schiemer et al. (2020), the value of the Vjosa as one of the few remaining reference sites for dynamic floodplains in Europe is pointed out.

Concerning the **Bern Convention**, Albania is obliged to take all appropriate measures to ensure the conservation of the habitats of wild floral and faunal species. The Convention is binding. As stated in chapter "Legal Framework and Evaluation/Assessment Criteria", the selection and effective protection of 'Areas of Special Conservation Interest' is regarded as one of the main tools that allows Parties to comply with their obligations. To date, there is no adopted **Emerald Network** site in Albania. The current list of officially nominated candidate Emerald sites (Convention on the conservation of European wildlife and natural habitats, Standing Committee, December 2019) lists at least 25 sites. Some of its tributaries are inside this network but the Vjosa itself is only connected at one edge. This is difficult to understand against the background of its documented value. The protection of the Vjosa area seems to be crucial for reaching the goals of the Convention in Albania. Very high species numbers, endemic and endangered species, and endangered habitats in a large area, as well as more than 140 species listed in Annexes I, II, or III of the Bern Convention (see Table 11), including migratory ones, emphasise this. A project with such drastic consequences and the predicted loss or severe damage of natural and near-natural river and floodplain landscapes of more than 3 500 hectares (including those areas affected by a reduction of hydromorphodynamics) must be seen as contrary to the objectives of the Bern Convention.

Provided that Albania will not cancel its integration process into the European Union, it must approximate its national legislation and assessment procedures with the legislation/regulations of the European Union. Linked to the **Birds Directive** and the **Habitats Directive** this means, inter alia, that appropriate sites for bird protection and for the protection of the species of Annex II and habitats of Annex I of the Habitats Directive must be selected and protected, following a specific process in coordination with the EU Commission. It is not possible to go into detail in this report, but obviously a site like the Vjosa, with such a high number of (well-studied) habitat types from Annex I of the Habitats Directive, more than 30 Annex I-Bird Directive species (some of them with a remarkable amount of the national population), and Annex II-Species of the Habitats Directive, should be included in the Natura 2000 network of protected sites of European importance. This importance is underlined by an exemplary comparison, shown in Table 19, of selected habitat types.

Habitat type Annex I	Sites within EU (no.)	Habitat area in sites within EU (ha)	Median (ha)	Maximum (ha)	Top quartile	Investigation area, Vjosa 2019 (ha)*	% of EU habitat area in site
3220	434	109 090,5	13,2	52077,5	57,4	216,3	0,2
3230	88	3 669,5	2,9	704	19,9	44,7	1,2
3240	540	83 420,5	7,3	52077,5	29	66,1	0,1
3250	222	36 506,6	9,6	9559,2	78,3	643,9	1,8
6210	4444	874 815,0	11	35827,8	66,6	526,6	0,1
92C0	153	16 678,4	35,7	1592,3	90,7	34,2	0,2
92D0	799	82 312,6	13,4	6995,2	59,3	277,24	0,3

*wetted area not included

Table 19. Selected habitat types in the floodplain zone at Poçem and Kalivaç of the Vjosa investigation area (2019; see Table 5) in relation to the EU-wide inventory of Natura 2000 sites, according to the Habitat Directive. Based on the Natura 2000 Dataset published in 2018 (PublicNatura2000End2017). Datasets with no entries for COVER_HA or with a value of 0 were not included (N = 12 843 for the selected habitat types).

Table 19 shows that the Vjosa investigation area in 2019 alone (see chapter "Flora and vegetation"), which comprises only a part of the total Vjosa area, hosts in two cases high shares (1.2 and 1.8%) of the EU-wide reported area of a habitat type (dark green): Alpine rivers and their ligneous vegetation with Myricaria germanica (3230) and Constantly flowing Mediterranean rivers with Glaucium flavum (3250). In three other cases, the percentage reaches at least 0.2or 0.3% (light green). With one exception the habitat area in the Vjosa investigation area is nearly as high or distinctively higher than the median over all reported sites with available data. Despite the preliminary character of the EU-wide dataset, these are extremely high values for a single site, underlining its value on an international scale.

Further, the results of the present report also illustrate how severe the predicted impacts of the Kalivaç (and the Poçem) dam project would be, even if it does not present a detailed analysis of the potential effects (which would be the task of an EIA and a Natura 2000 impact assessment, if those projects should be followed up). See, therefore, chapter "Impact of Kalivaç HPP": The impoundment, as the most severely affected area, shows the total default of around 40% of all evaluated species, many of them characteristic species of Annex I habitat types. However, it is pointed out that the river stretches downstream and upstream of the sites (including tributaries) exhibit marked impacts from the planned HPPs.

Regarding a **Natura 2000** impact assessment under Article 6(3) of the Habitats Directive (specific regulations for a site before or during the notification process are not considered here), the following aspects are of specific importance:

The assessment carried out may not have gaps and 'must contain complete, precise, and definitive findings and conclusions capable of removing all reasonable scientific doubt as to the effects of the proposed works on the protected site concerned' (European Court of Justice, judgement of 12 April 2018, C-323/17, judgements of 21 July 2016, C-387/15, C-388/15).

Even if, under certain circumstances, losses of protected habitats and species in a Natura 2000 site could be evaluated as not significantly (adversely) affecting the integrity of that site (e.g., for guidance on setting thresholds of significance in Germany, see European Commission 2018, p. 30), such thresholds are low. The severe impacts predicted in this report with lasting and irreparable losses, e. g., of Annex I habitats, will under no circumstances allow a positive assessment of the Kalivaç (and/or Poçem) Project.

Even if public interest is given, the grant of a derogation would require imperative reasons for overriding public interest, and the absence of alternative solutions. It is highly doubtful that, regarding the outstanding value of the Vjosa and the public interest in the conservation of biodiversity, those 'imperative reasons' could be given for an HPP in this specific case. The question of alternative solutions is not covered here.

An additional objective associated with the grant of a derogation would be to take all compensatory measures necessary to ensure that the overall coherence of Natura 2000 is protected. It does not appear to be feasible/possible to realise compensatory measures to the necessary extent.

Concerning the **EIA Directive**, an appropriate evaluation process is of high importance. Referring to Article 3, the 'EIA shall identify, describe, and assess in an appropriate manner, in the light of each individual case, the direct and indirect significant effects of a project on the following factors: (a) population and human health; (b) biodiversity, with particular attention to species and habitats protected under Directive 92/43/EEC and Directive 2009/147/EC; (c) land, soil, water, air, and climate; (d) material assets, cultural heritage, and the landscape; and (e) the interaction between the factors referred to in points (a) to (d).' An appropriate evaluation is not conducted if those factors are not suitably listed or if only a minimal amount of information is provided, without an analysis of the specific situation. The assessment results of an EIA must not simply be reduced to information, that a factor could be negatively affected, but should provide concrete and sufficient statements about the quantity and quality of effects. 'Investments in hydropower need to comply with national and international nature protection and water management obligations, ensure public participation and consultation, and guarantee high quality EIA reports that include impact assessments on nature and biodiversity' (European Commission, Commission Staff Working Document, Albania 2019 Report).

The claim for high quality EIA reports is in line with Article 3 (3) of the Treaty on European Union, through which a 'high level of protection and improvement of the quality of the environment' shall be established.

Additionally the Convention on EIAs in a Transboundary Context produced at Espoo (Finland), on 25 February 1991 (Albania signed this Convention in 1991), as amended by the 2nd amendment in 2004, requires the state in which a project is planned to investigate and assess the environmental impacts of the project on neighbouring states, if the project is likely to have significant, adverse, transboundary environmental impacts. Undoubtably this is the case in the Kalivaç/Poçem projects, because of the blockage of migratory fish species from the upstream river ecosystem, including those parts situated in Greece. One example of such a fish species is the European eel (see. chapters "Fish" and "Impacts on fish"). A sufficient EIA must therefore investigate the environmental impacts on Greece and include Greece as an affected party in the EIA process as far as it is claimed by the Convention and/or the EIA Directive.

The admission of the project under the provisions of the **Water Framework Directive** seems to be doubtful. The European Court of Justice clarified, that 'the Member States are required - unless a derogation is granted - to refuse authorisation for an individual project where it may cause a deterioration of the status of a body of surface water or where it jeopardises the attainment of good surface water status or of good ecological potential and good surface water chemical status [...]. The concept of the "deterioration of the status" of a body of surface water in Article 4(1)(a)(i) [...] must be interpreted as meaning that there is deterioration as soon as the status of at least one of the quality elements, within the meaning of Annex V of the Directive, falls by one class, even if that fall does not result in a fall in classification of the body of surface water as a whole' (European Court of Justice, Judgement of 1. July 2015, C-461/13).

CONCLUSIONS

PHOTO: **GREGOR SUBIC**

This report highlights the value of the Vjosa as one of the few remaining reference sites for dynamic floodplains in Europe. The morphological floodplain of the Vjosa is characterised by an exceptionally high near-natural status and is an exceptionally rare example in Europe. The high values of the habitats listed in the Habitat Directive underscore its value on an international scale. These protected habitats provide the basis for a highly endangered fauna and flora. More than 1100 detected species, including high numbers and abundances of protected and endangered species listed in national and international laws and conventions, highlight the significance of this natural environment.

The investigations carried out so far were time-limited and reveal only a snapshot of the area. More intense inter- and multidisciplinary studies would be a prerequisite for the in-depth evaluation of the potential impacts caused by HPPs. However, the present study is a sound baseline survey, listing previously documented fauna and flora, their status, and future developments under the prospected stress of an HPP. It also includes national and international guidelines and Directives.

The planned Kalivaç HPP would lead to a complete and irretrievable loss of more than 1000 ha of natural and near-natural river and floodplain landscape owing to damming upstream of the dam wall. As a result of the drastically reduced hydromorphodynamics and the bed-load deficit, large areas of typical riparian habitat would also be lost downstream of the dam. These interventions cannot be compensated for by mitigation measures and would lead to the destruction of one of the most pristine wild river landscapes in Europe. In summary, 870 ha of Habitat-Directive habitats would be directly lost in the area of the reservoir. Furthermore, at least 2800 ha of Habitat-Directive habitats would be directly affected downstream, through reduced morphodynamics, and, over time, the loss of these habitats could be expected.

According to the EU Water Framework Directive, any deterioration of the status of a given waterbody is prohibited. As the Vjosa River currently represents a reference status, the various local and regional impacts of an HPP would clearly violate EU water laws. The severe impacts predicted in this report, with lasting and irreparable losses, will under no circumstances allow a positive assessment of the Kalivaç (and/or Poçem) Project. Even if public interest is given, the grant of a derogation would require imperative reasons for overriding public interest, and the absence of alternative solutions.

The present study demonstrates a high local extinction risk in the study area owing to the planned HPP, which is not limited to the immediate project area, but also includes the downstream sections and the Vjosa-Narta Delta. Since many internationally protected species are affected, for which the Albanian government has taken responsibility by signing various international and national agreements, prior to any physical intervention in the Vjosa River, it must be ensured that further populations of the affected species occur in Albania and neighbouring countries to prevent national or wider-level extinction.

In summary, there are three important reasons to resist the construction of an HPP in the Vjosa River:

Reason 1

Ecological degradation of a large, unique river system and a subsequent loss of biodiversity

Reason 2

High economic costs owing to sediment-related problems

Reason 3

Violation of signed laws, Conventions, and Directives

Aside from the international relevance of this system as a reference site, local communities depend on the rich Vjosa floodplain for agriculture and as a setting for their specific cultural heritage.

The Vjosa represents a unique riverine ecosystem in Europe.

The fauna and flora of this highly dynamic river represent the last inhabitants of a dwindling river refuge. Their survival depends on well-planned management of both the catchment and the surrounding areas.

At the given pace of habitat modification in the wake of economic growth, the Vjosa and her catchment need to be included in international conservation and management schemes. As a model for restoration measures, and a cradle of biodiversity and natural heritage, this river and its community are too important to be lost.

ABKONS, 2019a. ESIA Scoping Assessment Report for the Proposed Kalivaç HPP.

ABKONS, 2019b. Non-technical Summary on Detailed EIA; Project: Kalivaç Hydropower Plant.

Agostinho, A.A., Pelicice, F.M., Gomes, L.C., 2008. Dams and the fish fauna of the Neotropical region: impacts and management related to diversity and fisheries. Brazilian journal of biology 68, 1119-1132.

Antonelli, C., Provansal, M., Vella, C., 2004. Recent morphological channel changes in a deltaic environment. The case of the Rhône River, France. Geomorphology 57, 385-402.

Aqem Consortium, 2002. Manual for the application of the AQEM system. A comprehensive method to assess European streams using benthic macroinvertebrates, developed for the purpose of the Water Framework Directive. Version 1, 2002.

Balon, E.K., 1975. Reproductive guilds of fishes: a proposal and definition. Journal of the Fisheries Board of Canada 32, 821-864.

Baras, E., Lucas, M.C., 2001. Impacts of man's modifications of river hydrology on the migration of freshwater fishes: a mechanistic perspective. International Journal of Ecohydrology & Hydrobiology 1, 291-304.

Bauernfeind, E., Soldán, T., 2012. The mayflies of Europe (Ephemeroptera). Apollo, Ollerup, 781 pp.

Baxter, R., 1977. Environmental effects of dams and impoundments. Annual Review of Ecology and Systematics 8, 255-283.

Bego, K., Qirjo, M., Bego, F., 2019. Long-term coastal habitat dynamics in Buna delta severely influenced by hydropower dams along upstream Drini River., In Poster at the International Conference "Challenges in Technological and Environmental Approaches".

Birk, S., Bonne, W., Borja, A., Brucet, S., Courrat, A., Poikane, S., Solimini, A., Van De Bund, W., Zampoukas, N., Hering, D., 2012. Three hundred ways to assess Europe's surface waters: an almost complete overview of biological methods to implement the Water Framework Directive. Ecological indicators 18, 31-41.

BMLFUW, 2012. Leitfaden zum Bau von Fischaufstiegshilfen. Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft,, 102.

Bormann, F.H., Likens, G.E., 1979. Catastrophic disturbance and the steady state in northern hardwood forests: A new look at the role of disturbance in the development of forest ecosystems suggests important implications for land-use policies. American Scientist 67, 660-669.

Boukal, D., Boukal, M., Fikáček, M., Hájek, J., Klečka, J., Skalický, S., Šťastný, J., Trávníček, D., 2007. Katalog vodních brouků České republiky−Catalogue of water beetles of the Czech Republic (Coleoptera: Sphaeriusidae, Gyrinidae, Haliplidae, Noteridae, Hygrobiidae, Dytiscidae, Helophoridae, Georissidae, Hydrochidae, Spercheidae, Hydrophilidae, Hydraenidae, Scirtidae, Elmidae, Dryopidae, Limnichidae, Heteroceridae, Psephenidae). Klapalekiana 43, 1-289.

Braasch, D., 1995. Zur Bewertung rheotypischer Arten in Fließgewässern des Landes Brandenburg. Naturschutz und Landschaftspflege in Brandenburg 4, 4-15.

Buczyński, P., Przewoźny, M., Zawal, A., Zgierska, M., 2011. On the occurrence of Potamophilus acuminatus (FABRICIUS, 1772)(Coleoptera: Elmidae) in Poland. Baltic Journal of Coleopterology 11, 45-56.

Carson, M., 1984. The meandering-braided river threshold: a reappraisal. Journal of Hydrology 73, 315-334.

Carvajal-Quintero, J.D., Januchowski-Hartley, S.R., Maldonado-Ocampo, J.A., Jézéquel, C., Delgado, J., Tedesco, P.A., 2017. Damming fragments species' ranges and heightens extinction risk. Conservation Letters 10, 708-716.

Cataudella, S., Crosetti, D., Ciccotti, E., Massa, F., 2014. Sustainable management in Mediterranean coastal lagoons: interactions among capture fisheries, aquaculture and the environment. Mediterranean coastal lagoons: sustainable management and interactions among aquaculture, capture fisheries and environment. Ed. by S. Cataudella, D. Crosetti, and F. Massa. General Fisheries Commission for the Mediterranean. Studies and Reviews.

Commission of the European Communities, 2000. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. OJ L 327, 1-73.

Council of the European Union, 2007. Council Regulation (EC) No 1100/2007 of 18 September 2007 establishing measures for the recovery of the stock of European eel, pp. 17-23, Official Journal of the European Union.

Crivelli, A.J., 1996. The freshwater fish endemic to the northern Mediterranean region: an action plan for their conservation. Tour du Valat.

De Sostoa, A., Lobón-Cerviá, J., 1989. Fish and fisheries of the River Ebro: actual state and recent history. Historical Change of Large Alluvial Rivers: Western Europe. John Wiley & Sons New York. 1989. p 233-247. 4 fig, 3 tab, 15 ref.

Dekker, W., 2003. On the distribution of the European eel (Anguilla anguilla) and its fisheries. CANADIAN JOURNAL OF FISHERIES AND AQUATIC SCIENCES 60, 787-799.

Den Hartog, C., Van den Brink, F., Van der Velde, G., 1992. Why was the invasion of the river Rhine by Corophium curvispinum and Corbicula species so successful? Journal of Natural History 26, 1121-1129.

Dole-Olivier, M.-J., 2011. The hyporheic refuge hypothesis reconsidered: a review of hydrological aspects. Marine and Freshwater Research 62, 1281-1302.

Dudgeon, D., Arthington, A.H., Gessner, M.O., Kawabata, Z.-I., Knowler, D.J., Lévêque, C., Naiman, R.J., Prieur-Richard, A.-H., Soto, D., Stiassny, M.L., 2006. Freshwater biodiversity: importance, threats, status and conservation challenges. Biological reviews 81, 163-182.

Dynesius, M., Nilsson, C., 1994. Fragmentation and flow regulation of river systems in the northern third of the world. Science 266, 753-762.

Eco-Masterplan for Balkan rivers, 2018. "Save the Blue Heart of Europe" campaign.

Economouà, A., Giakoumià, S., Vardakasà, L., Barbierià, R., 2007. The freshwater ichthyofauna of Greece-an update based on a hydrographic basin survey. Mediterranean Marine Science 8, 91-166.

Edwards, R.J., 1978. The effect of hypolimnion reservoir releases on fish distribution and species diversity. Transactions of the American Fisheries Society 107, 71-77.

Egger, G., Randl, M., Drescher, A., 2019. Scientific programme: Baseline surveys for an Environmental Impact Assessment of River Vjosa in Albania: Vegetation and Riparian Habitats. 118.

EIFAC/ICES, 2008. Report of the 2007 session of the Joint EIFAC/ICES Working Group on EELS. Bordeaux, France, 3-7 September 2007, FAO European Inland Exploration of the Sea., p. 524, EIFAC Occasional Pap. 39.

ESRI, 2011. ArcGIS Desktop. CA: Environmental Systems Research Institute., Redlands.

European Commission, 2007. Interpretation manual of European Union habitats. European Commission-DG Environment, Eur 27.

Fame Consortium, 2005. Manual for the application of the European Fish Index-EFI. A fish-based method to assess the ecological status of European rivers in support of the Water Framework Directive. Version 1.

FAO, 2002. Fish passes: design, dimensions, and monitoring.

Farkač, J., Král, D., Škorpík, M., 2005. Červený seznam ohrožených druhů České republiky. Bezobratlí. Agentura ochrany přírody a krajiny ČR, Praha 73.

Faulks, L.K., Gilligan, D.M., Beheregaray, L.B., 2011. The role of anthropogenic vs. natural in-stream structures in determining connectivity and genetic diversity in an endangered freshwater fish, Macquarie perch (Macquaria australasica). Evolutionary Applications 4, 589-601.

Fittkau, E., Reiss, F., 1983. Versuch einer Rekonstruktion der Fauna europäischer Ströme und ihrer Auen. Archiv für Hydrobiologie 97, 1-6.

Fochetti, R., De Figueroa, J.M.T., 2007. Global diversity of stoneflies (Plecoptera; Insecta) in freshwater, In Freshwater Animal Diversity Assessment. pp. 365-377. Springer.

Fontes, H., Olivier, A., Sacdanaku, E., Thibault, M., 2019. Biodiversity survey of the Vjosa River catchment − Poçem & Kalivaç areas (Albania), May 2019. 61.

Froese, R., Pauly, D., 2010. FishBase. Fisheries Centre, University of British Columbia.

Gabbud, C., Robinson, C.T., Lane, S.N., 2019. Summer is in winter: Disturbance-driven shifts in macroinvertebrate communities following hydroelectric power exploitation. Science of the Total Environment 650, 2164-2180.

Gehrke, P., Gilligan, D., Barwick, M., 2002. Changes in fish communities of the Shoalhaven River 20 years after construction of Tallowa Dam, Australia. River research and Applications 18, 265-286.

Geiser, R., 1998. Rote Liste der Käfer (Coleoptera). In Rote Liste gefährdeter Tiere Deutschlands. ed. R.B. Binot M., Boye P., Gruttke H., Pretscher P. , pp. 168−230. Bundesamt für Naturschutz, Bonn-Bad Godesberg.

Gilvear, D.J., Greenwood, M.T., Thoms, M.C., Wood, P.J., 2016. River science: research and management for the 21st century. John Wiley & Sons.

Google, 2019. Google Earth, www.google.com.

Graf, W., Pauls, S.U., Vitecek, S., 2018. Isoperla vjosae sp. n., a new species of the Isoperla tripartita group from Albania (Plecoptera: Perlodidae). Zootaxa 4370, 171-179.

Graf, W.L., 2006. Downstream hydrologic and geomorphic effects of large dams on American rivers. Geomorphology 79, 336-360.

Granado-Lorencio, C., 1991. The effect of man on the fish fauna of the River Guadalquivir, Spain. Fisheries research 12, 91-100.

Greimel, F., Schülting, L., Graf, W., Bondar-Kunze, E., Auer, S., Zeiringer, B., Hauer, C., 2018. Hydropeaking impacts and mitigation. Riverine Ecosystem Management; Schmutz, S., Sendzimir, J., Eds, 91-110.

Hauer, C., Aigner, H., Fuhrmann, M., Holzapfel, P., Rindler, R., Pessenlehner, S., Pucher, D., Skrame, K., Liedermann, M., 2019. Measuring of sediment transport and morphodynamics at the Vjosa River / Albania, p. 85.

Hennekens, S.M., Schaminée, J.H., 2001. TURBOVEG, a comprehensive data base management system for vegetation data. Journal of vegetation science 12, 589-591.

Hill, M., 1979. TWINSPAN. A FORTRAN program for arranging multivariate data in an ordered two-way table by classification of the individuals and their attributes. Ecology and Systematics, Cornell University: Ithaca, New York.

Holecová, M., Franc, V., 2001. Red (Ecosozological) list of beetles (Coleoptera) of Slovakia. Red List of Plants and Animals of Slovakia. Ochr. Prír 20, 111-128.

Hughes, R.M., Larsen, D.P., Omernik, J.M., 1986. Regional reference sites: a method for assessing stream potentials. Environmental Management 10, 629-635.

IUCN Standards and Petitions Committee, 2019. Guidelines for Using the IUCN Red List Categories and Criteria., ed. P.b.t.S.a.P. Committee.

Jäch, M.A., Dietrich, F., Raunig, B., 2005. Rote Liste der Zwergwasserkäfer (Hydraenidae) und Krallenkäfer (Elmidae) Österreichs (Insecta: Coleoptera). na.

Jacoby, D., Gollock, M., 2014. Anguilla anguilla. The IUCN red list of threatened species.

Jungwirth, M., Haidvogel, G., Moog, O., Muhar, S., Schmutz, S., 2003. Angewandte Fischökologie an Fließgewässern. p552; Facultas Universitätsverlag, Wien. ISBN 3-8252-2113-X.

Jungwirth, M., Schmutz, S., Weiss, S., 1998. Fish migration and fish bypasses. Fishing News Books Oxford.

Junk, W.J., 1997. General aspects of floodplain ecology with special reference to Amazonian floodplains, In The Central Amazon Floodplain. pp. 3-20. Springer.

Kesh & Sogreah Consultants, 2008. Consultants' Services for assessment of power generation potential of selected Albanian Rivers. , In Draft Report for Vjosa river basin., Tirana.

Klausnitzer, B., 1996. Käfer im und am Wasser. Westarp Wissenschaften. Spektrum Akademische Verlag, Magdeburg−Heidelberg−Berlin−Oxford.

Kondolf, G.M., 1997. PROFILE: hungry water: effects of dams and gravel mining on river channels. Environmental Management 21, 533-551.

Kovács, T., Ambrus, A., 2000. Two rare plecopterans from the Rába: Agnetina elegantula (Klapálek, 1905) and Marthamea vitripennis (Burmeister, 1839)(Plecoptera: Perlidae). Miscellanea zoologica hungarica 13.

Krystufek, B., Reed, J.M., 2004. Balkan Biodiversity: Pattern and process in the European hotspot. Kluwer Academic Press.

Larinier, M., 2001. Environmental issues, dams and fish migration. FAO fisheries technical paper 419, 45-89.

Lasne, E., Lek, S., Laffaille, P., 2007. Patterns in fish assemblages in the Loire floodplain: the role of hydrological connectivity and implications for conservation. Biological conservation 139, 258-268.

Lawton, J.H., May, R.M., Raup, D.M., 1995. Extinction rates. Oxford University Press Oxford.

Liermann, C.R., Nilsson, C., Robertson, J., Ng, R.Y., 2012. Implications of dam obstruction for global freshwater fish diversity. BioScience 62, 539-548.

Lövei, G.L., 1997. Global change through invasion. Nature 388, 627-628.

MacArthur, R.H., Wilson, E.O., 1967. Island biogeography. Princeton.

MacNamara, R., McCarthy, T.K., 2014. Silver eel (Anguilla anguilla) population dynamics and production in the River Shannon, Ireland. Ecology of Freshwater Fish 23, 181-192.

McCleave, J.D., 2003. Spawning areas of the Atlantic eels, In Eel biology. pp. 141-155. Springer.

McMahon, T.E., Matter, W.J., 2006. Linking habitat selection, emigration and population dynamics of freshwater fishes: a synthesis of ideas and approaches. Ecology of Freshwater Fish 15, 200-210.

Meulenbroek, P., Hammerschmied, U., Schmutz, S., Weiss, S., Schabuss, M., Zornig, H., S., Shumka & Schiemer, F. (2020). Conservation Requirements of European Eel (Anquilla anquilla) in a Balkan Catchment. Sustainability, 12(20), 8535.

Meulenbroek, P., Shumka, S., Schiemer, F., 2018a. First reconnaissance of habitat partitioning and fish diversity in the alluvial zone of the river Vjosa, Albania. Acta ZooBot Austria 155, 177–186.

Meulenbroek, P., Shumka, S., Schiemer, F., 2018b. First reconnaissance of habitat partitioning and fish diversity in the alluvial zone of the river Vjosa, Albania. Acta ZooBot Austria 155, 177-186.

Mey, W., 2006. Ein Blick zurück: Köcherfliegen am Rhein bei St. Goarshausen im Jahre 1890 (Insecta, Trichoptera). Lauterbornia 58, 155-167.

Ministry of Defense (Ministria e Mbrojtjes), 1985. Albanian topographic map, 1:200 000.

Monaghan, M.T., Spaak, P., Robinson, C.T., Ward, J., 2002. Population genetic structure of 3 alpine stream insects: influences of gene flow, demographics, and habitat fragmentation. Journal of the North American Benthological Society 21, 114-131.

Moog, O., Schmutz, S., Schwarzinger, I., 2018. Biomonitoring and bioassessment. Riverine Ecosystem Management 371.

Nanson, G.C., Knighton, A.D., 1996. Anabranching rivers: their cause, character and classification. Earth surface processes and landforms 21, 217-239.

Nilsson, C., Reidy, C.A., Dynesius, M., Revenga, C., 2005. Fragmentation and flow regulation of the world's large river systems. Science 308, 405-408.

Ofenböck, T., Graf, W., Hartmann, A., Huber, T., Leitner, P., Stubauer, I., Moog, O., 2011. Abschätzung des ökologischen Zustandes von Stauen auf Basis von Milieufaktoren. Bundesministerium für Land-und Forstwirtschaft, Umwelt und Wasserwirtschaft: Vienna, Austria.

Osterkamp, W., Hedman, E., 1977. Variation of width and discharge for natural high-gradient stream channels. Water Resources Research 13, 256-258.

Pils, G., Ingeborg, J., Gottschlich, G., 2016. Illustrated Flora of Albania: with 80 colour drawings by Ingeborg Jost and an illustrated account on Genus Hieracium by Güter Gottschlich.

Poff, N.L., Allan, J.D., Bain, M.B., Karr, J.R., Prestegaard, K.L., Richter, B.D., Sparks, R.E., Stromberg, J.C., 1997. The natural flow regime. BioScience 47, 769-784.

Poff, N.L., Hart, D.D., 2002. How dams vary and why it matters for the emerging science of dam removal: an ecological classification of dams is needed to characterize how the tremendous variation in the size, operational mode, age, and number of dams in a river basin influences the potential for restoring regulated rivers via dam removal. BioScience 52, 659-668.

Poff, N.L., Olden, J.D., Merritt, D.M., Pepin, D.M., 2007. Homogenization of regional river dynamics by dams and global biodiversity implications. Proceedings of the National Academy of Sciences 104, 5732-5737.

Rakaj, N., Flloko, A., 1995. Ichthyofauna of Albania. University of Tirana, Tirana, 700.

Randl, M., in prep. Potential impacts of hydropowerplants on vegetation dynamics at the hydromorphological undisturbed river Vjosa, Albania. . University of Natural Resources and Life Sience, Vienna.

Reichelt, G., Wilmanns, O., 1973. Vegetationsgeographie. Westermann.

Ribera, I., 2000. Biogeography and conservation of Iberian water beetles. Biological conservation 92, 131-150.

RStudio, 2015. RStudio: Integrated Development for R. RStudio, Boston.

Ru, H., Li, Y., Sheng, Q., Zhong, L., Ni, Z., 2020. River damming affects energy flow and food web structure: a case study from a subtropical large river. Hydrobiologia 847, 679-695.

Rudd, J.W., Hecky, R., Harris, R., Kelly, C., 1993. Are hydroelectric reservoirs significant sources of greenhouse gases. Ambio 22, 246-248.

Schiemer, F., Beqiraj, S., Drescher, A., Graf, W., Egger, G., Essl, F., Frank, T., Hauer, C., Hohensinner, S., Miho, A., Meulenbroek, P., Paill, W., Schwarz, U., Vitecek, S., 2020. The Vjosa River corridor: a model of natural hydro-morphodynamics and a hotspot of highly threatened ecosystems of European significance. Landscape Ecology, 1-16.

Schiemer, F., Drescher, A., Hauer, C., Schwarz, U., 2018. The Vjosa River corridor: a riverine ecosystem of European significance. Acta ZooBot Austria 155, 1-40.

Schiemer, F., Waidbacher, H., 1992. Strategies for conservation of a Danubian fish fauna. River conservation and management 26, 363-382.

Schletterer, M., Bauernfeind, E., Lechthaler, W., 2015. Larval redescription of Prosopistoma pennigerum (Müller, 1785) from the River Volga near Rzhev, Tver Region, Russia (Insecta: Ephemeroptera), In Proceedings of the Joint Meeting of the XIV International Conference on Ephemeroptera and the XVIII International Symposium on Plecoptera in Aberdeen [submitted].

Schletterer, M., Füreder, L., 2008. Entomological notes on all described species of the mayfly-family Prosopistomatidae (Insecta: Ephemeroptera). Berichte des naturwissenschaftlich-medizinischen Vereines Innsbruck 95, 65-75.

Schletterer, M., Füreder, L., 2009. The family Prosopistomatidae (Ephemeroptera): a review on its ecology and distribution, with particular emphasis on the European species Prosopistoma pennigerum Müller, 1785. Aquatic Insects 31, 603-620.

Schletterer, M., Kuzovlev, V., 2007. First record of Prosopistoma pennigerum from the Russian Federation (Ephemeroptera: Prosopistomatidae). Zoosystematica Rossica 16, 169-172.

Schletterer, M., Weiss, S., Graf, W., 2018. Ecological and genetic considerations regarding Prosopistoma pennigerum (MÜLLER, 1785) from the Volga (Russia) and Vjosa (Albania), In XV International Conference on Ephemeroptera and XIX International Symposium on Plecoptera., Aracruz, Brazil.

Schmutz, S., Moog, O., 2018. Dams: ecological impacts and management, In Riverine Ecosystem Management. pp. 111-127. Springer, Cham.

Schmutz, S., Sendzimir, J., 2018. Riverine ecosystem management. Springer International Publishing Switzerland.

Schmutz, S., Zauner, G., Eberstaller, J., Jungwirth, M., 2001. Die „Streifenbefischungsmethode ": Eine Methode zur Quantifizierung von Fischbeständen mittelgrosser Fliessgewässer. Österreichs Fischerei 54, 14-27.

Schülting, L., Feld, C.K., Graf, W., 2016. Effects of hydro- and thermopeaking on benthic macroinvertebrate drift. Science of the Total Environment 573, 1472-1480.

Shumka, S., Meulenbroek, P., Schiemer, F., Šanda, R., 2018. Fishes of River Vjosa–an annotated checklist. Acta ZooBot Austria 155, 163-176.

Tesch, F., Rohlf, N., 2003. Migration from continental waters to the spawning grounds, In Eel Biology. pp. 223-234. Springer.

Thorp, J.H., Thoms, M.C., Delong, M.D., 2006. The riverine ecosystem synthesis: biocomplexity in river networks across space and time. River research and Applications 22, 123-147.

Tichý, L., 2002. JUICE, software for vegetation classification. Journal of vegetation science 13, 451-453.

Tockner, K., Stanford, J.A., 2002. Riverine flood plains: present state and future trends. Environmental conservation 29, 308-330.

Travis, J., 2003. Climate change and habitat destruction: a deadly anthropogenic cocktail. Proceedings of the Royal Society of London. Series B: Biological Sciences 270, 467-473.

Tuan, T.A., Rao, N.P., Gahalaut, K., Trong, C.D., Chien, C., Mallika, K., 2017. Evidence that earthquakes have been triggered by reservoir in the Song Tranh 2 region, Vietnam. Journal of Seismology 21, 1131-1143.

USGS, 2018. Declassified satellite images. CORONA satellite aerial images 1960-1975 (Declass 1 (1996)), https://earthexplorer.usgs.gov/ U.S. Geological Survey.

Van Cappellen, P., Maavara, T., 2016. Rivers in the Anthropocene: global scale modifications of riverine nutrient fluxes by damming. Ecohydrology & Hydrobiology 16, 106-111.

Vanicek, C.D., 1970. Distribution of Green River fishes in Utah and Colorado following closure of Flaming Gorge dam. The Southwestern Naturalist, 297-315.

Waidbacher, H., Drexler, S.-S., Meulenbroek, P., 2018. Danube Under Pressure: Hydropower Rules the Fish, In Riverine Ecosystem Management. eds S. Schmutz, J. Sendzimir, pp. 473-489. Springer, Cham.

Ward, J., Tockner, K., Schiemer, F., 1999. Biodiversity of floodplain river ecosystems: ecotones and connectivity1. River research and Applications 15, 125-139.

Ward, J.V., Stanford, J., 1995. Ecological connectivity in alluvial river ecosystems and its disruption by flow regulation. Regulated Rivers: Research & Management 11, 105-119.

Whittier, T.R., Stoddard, J.L., Larsen, D.P., Herlihy, A.T., 2007. Selecting reference sites for stream biological assessments: best professional judgment or objective criteria. Journal of the North American Benthological Society 26, 349-360.

Wohl, E., 2019. Forgotten legacies: Understanding and mitigating historical human alterations of river corridors. Water Resources Research 55, 5181-5201.

Wohl, E., Bledsoe, B.P., Jacobson, R.B., Poff, N.L., Rathburn, S.L., Walters, D.M., Wilcox, A.C., 2015. The natural sediment regime in rivers: broadening the foundation for ecosystem management. BioScience 65, 358-371.

Zhong, Y., Power, G., 1996. Environmental impacts of hydroelectric projects on fish resources in China. Regulated Rivers: Research & Management 12, 81-98.

Zwick, P., 1984. Marthamea beraudi (Navás) and its European congeners (Plecoptera: Perlidae), In Annales de Limnologie-International Journal of Limnology. pp. 129-139. EDP Sciences.

Zwick, P., 1992. Stream habitat fragmentation—a threat to biodiversity. Biodiversity & Conservation 1, 80-97.