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ECRR
European Centre for River Restoration

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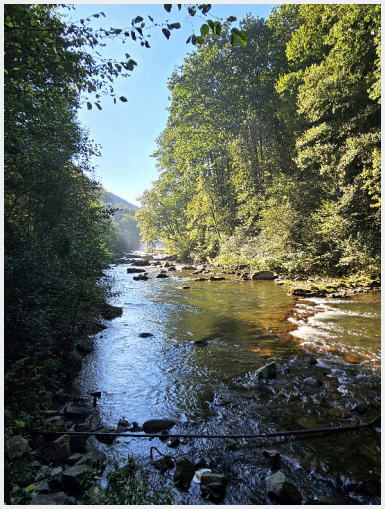
Editorial

EU LIFE Programme: Leading the Way in River Basin Restoration and Conservation



The **EU LIFE programme** funds projects that protect the environment and promote climate action across Europe. It supports innovative initiatives at local and regional levels, enabling projects that restore and conserve natural habitats, promote biodiversity and enhance resource efficiency. The programme helps translate EU policies into tangible actions that benefit the environment and communities.

The **Dordogne LIFE project** focuses on restoring the natural aquatic and alluvial habitats of the Dordogne River. It aims to improve the ecological status by restoring spawning grounds for migratory fish species and ecologically restoring abandoned gravel pits and oxbow lakes.

The **Four Rivers for LIFE project** aims to restore the ecological quality of four major rivers in south Wales by addressing multiple pressures such as climate change, habitat degradation, water quality, migration barriers, and invasive species.

The **LIFE Dee River project** is a major large-scale project to transform the River Dee and its catchment by restoring the river and surroundings back to its natural state, including the removal of the Erbistock weir.

The **LIFE CONNECTS project** aims to improve ecosystem functions and services in seven rivers in southern Sweden by removing barriers, creating fish passages, and restoring degraded river habitats.

The **Improve Aquatic LIFE** project aims to enhance aquatic ecosystems from source to sea in southern Sweden. The project focuses on improving connectivity, hydrology, and habitats through various restoration measures.

These magnificent projects show that the EU LIFE programme is instrumental in funding projects that improve ecological conditions and promote climate action across Europe. A sincere thank you to all the dedicated teams behind these projects and to the EU for their unwavering support in promoting a sustainable future. Thank you for your efforts and commitment!

On behalf of the ECRR Members and Board,
Bart Fokkens

EPIDOR

Co-funded by the European Union

LIFE rivière Dordogne

A pilot project for the restoration of large waterways

The LIFE project initiated by EPIDOR, the public territorial organisation for the Dordogne river basin, is implementing an action program on an unprecedented scale to restore the natural aquatic and alluvial habitats of the Dordogne river. This experience is feeding into a national debate led by the OFB on hydro-morphological river management strategies.

Hydro-morphological problems

The hydro-morphological restoration of watercourses is presently a course of action widely encouraged by public policy. However, while there is an increasing number of projects on small and medium-sized rivers, there are still very few on larger rivers, due to technical difficulties, complex usage issues and the considerable resources required.

The hydro-morphological balance of the Dordogne has been largely affected by the exploitation of river resources and the intensification of development since the middle of the 20th century. These transformations have had a significant impact on certain natural habitats and biodiversity.

As with many other French and European rivers, morpho-dynamic dysfunctions on the Dordogne are the consequence of past uses and current developments. The large hydroelectric dams on the upper Dordogne have altered hydrological regimes, and the frequency of morphogenic floods has fallen sharply. These events, which used to occur every two years, now only occur every ten years. The dams also block the flow of sediment from the upper basin.

Historical extraction of aggregates in the minor riverbed has caused the bed to sink by up to 4 metres in places. Some extraction pits, which have still not been filled in, continue to act as pebble traps, altering sediment transit. The installation of stabilising structures on riverbanks reduces transverse mobility and sediment remobilisation, thus slowing down the rebalancing processes.

As a result, over the last fifty years, the fluvial forms of the Dordogne river have been transformed, both longitudinally and altitudinally. The disruption of sediment transit and the reduction in the thickness of the alluvial mattress have caused the bed to sink by an average of

60 cm. The active channel belt width has been reduced by around 30 meters, with a tendency towards single channelisation (deepening of the bed, increased water velocity).

The disruption of sediment transit and the widespread incision of the Dordogne riverbed are causing profound changes for species and habitats of national and European interest. The blockage of course materials by large hydroelectric dams has severely degraded the breeding conditions of several migratory fish species of Community Interest.

Gravels, essential for the reproduction of lithophilic fish such as salmon, are progressively washed away by floods and are no longer replenished by large dams upstream. As a result, areas suitable for reproduction are shrinking. For shad and sea lamprey, the main reproduction sites are forced spawning grounds downstream of the Bergerac dams. These areas are suffering from gravel deficits, which are increasing and as a result reducing the survival of deposited eggs.

Widespread bed incision is leading to the disconnection of hydraulic annexes. These environments, normally home to a wide variety of interwoven habitats distributed in mosaics organized by river dynamics, are tending to become commonplace. Plant and animal biodiversity is declining, and species of heritage interest, often protected, are becoming more rare: Michel's nutsedge, false sedge, kingfisher, agile frog, otter, Aquitaine pike, to name but a few. Pioneer habitats such as willow shrublands are replaced by hardwood formations (ash-alder stands, black poplars, etc.), and aggradations are fixed by rapid vegetation growth.

FIGURE 1 *Degraded habitats © EPIDOR*

Restoration work and land management

To reduce morphological alterations caused by river development, the LIFE rivière Dordogne project aims to restore sites with high ecological potential. It comprises a total of around thirty projects. Part of the action plan concerns spawning grounds for migratory fish: on the upstream section, a dozen salmon spawning grounds will be restored through targeted injections of pebbles and gravel.

Feedback on this method has been satisfactory, and suggests that the surface area usable by fish could be doubled. For shad and sea lamprey, a pilot project is planned at the Mauzac hydroelectric dam, to transfer some of the sediment stored in the reservoir to forced spawning grounds located downstream.

A second set of works is aimed at the ecological restoration of ten dead-arms, two sections of riprap bank and four former gravel pits, now abandoned. The principles employed are mainly topographical reconfiguration through cut and fill, to restore a better hydraulic connection with the riverbed. The earthworks recreate natural, diversified river forms, conducive to the development of a variety of habitats. To help restore the river's sediment balance and minimize the carbon footprint of the works, the excavated sediment is reinjected as close as pos-

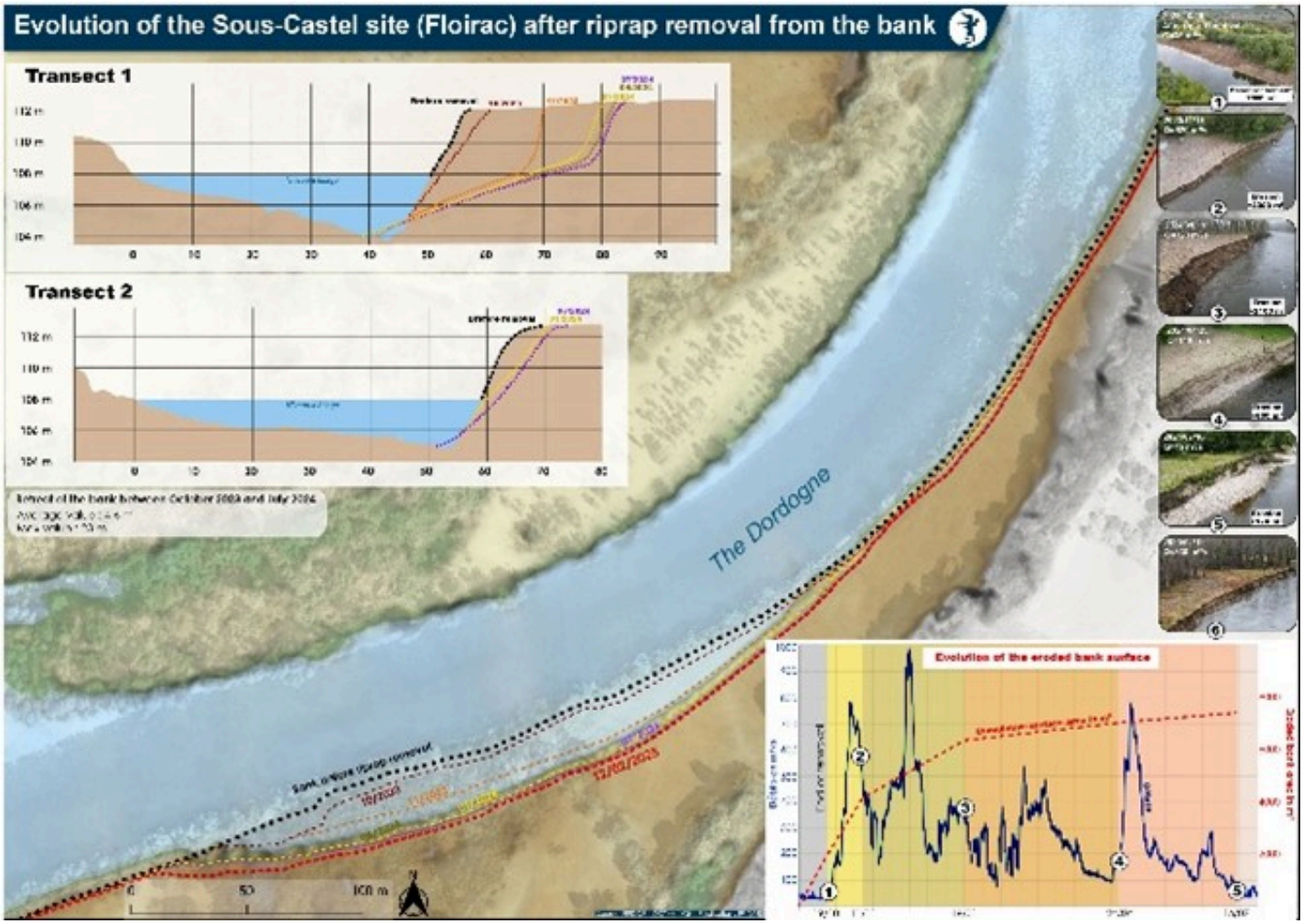


FIGURE 2 *Evolution after rip rap removal © EPIDOR*

sible to the riverbed. Particular attention is paid to invasive species, which are treated on site whenever possible. Results objectives and monitoring indicators are based on biological states and characteristic species.

FIGURE 3 *Floirac reconstruction works © EPIDOR*

On the Maison-Neuve alluvial plain (municipalities of Saint-Chamassy and le Buisson-de-Cadouin), for almost two centuries, various phases of exploitation and development have progressively reduced the spaces where the flora and fauna characteristic of alluvial environments could develop. Once frequently visited by water, the plain has been reshaped, becoming an ecologically very homogenous area with little connection to the river. In 2024, major work was carried out under the LIFE rivière Dordogne program, coordinated by EPIDOR, to restore 22 ha of alluvial environments.

Once renatured, the former Maison-Neuve gravel pit should be home to a greater number and diversity of plant and animal species. Benefits for the environment are also expected. These include improving the quality of natural areas. The reconnection of a wetland on the site to the Dordogne will make it more functional when the river overflows. This newly renatured area should provide favorable benefits for human activities, thanks in particular to:

- a 22-hectare flood control area;
- an area for self-purification of the water resource, with avoided denitrification costs estimated at 200,000 to 250,000 euros.
- maintenance of agricultural activity on the alluvial plain in the form of late-mown meadows.

To ensure better conservation and facilitate restoration work along the river continuum, the LIFE project aims to acquire land bordering the public river domain. The land targeted for acquisition is located alongside the river and contains habitats in a good state of conservation, or with potential for ecological restoration.

FIGURE 4 *Dordogne former Maison-Neuve gravel pit (1) © EPIDOR*

FIGURE 5 *Dordogne former Maison-Neuve gravel pit (2) © EPIDOR*

Initially, land acquisitions are carried out on sites concerned by restoration work, or in response to opportunities. In the longer term, a strategy involving the various players involved in land and nature conservation (local authorities, EPCIs, Conservatoire d'espaces naturels, Safer, départements, fishing and hunting federations) will make it possible to ensure the long-term viability of land actions.

Expected impacts and experiences

The LIFE project aims not only to improve the ecological status of natural environments, but also to push forward river-related planning and management policies. It is thus planned, in conjunction with government departments, to revise various regulatory measures in the light of the lessons learned from the LIFE project: biotope protection decrees, regulations governing hydroelectric works, directives concerning the restoration of alluvial gravel pits, etc.

All the French and European partners involved in the LIFE Dordogne project see it as an opportunity to develop a broader reflection on the technical and strategic aspects of river management. Coordinated by the OFB and its waterways resource centre, and fed by exchange sessions led by ANEB, this reflection will give rise to the drafting of a practical guide, in French and English, aimed at institutions concerned by this issue. Similar exchanges on a European scale with ECRR will be promoted in the form of a seminar organized in the Dordogne basin, as well as an international symposium.

For more information on the project: www.life-dordogne.eu.

Views and opinions expressed in the article are those of the author only and do not necessarily reflect those of the European Union or the beneficiaries of the project. Neither the European Union nor the beneficiaries can be held responsible for them.

FIGURE 6 *Floirac a while after the reconstruction works © EPIDOR*

Cyfoeth Naturiol Cymru Natural Resources Wales

Co-funded by the European Union

Four Rivers for LIFE project

Four Rivers for LIFE is a large-scale river restoration project to improve the condition of four major rivers in south Wales: Teifi, Cleddau, Tywi and Usk. These four rivers are classed as Special Areas of Conservation (SAC) which means they are of international importance for their wildlife and plants such as Atlantic salmon, lamprey, shad, otter and water crowfoot. All four rivers are currently in an unfavourable condition as a result of multiple pressures such as climate change, habitat degradation, water quality, migration barriers and invasive non-native species. A total of 776km of river will be improved in mid and south Wales as the project aims to restore the rivers to a better condition.

Description

The rivers support several habitats and species from bogs and floodplains to fish, otter, freshwater pearl mussel and floating water plantain. These habitats and species are all threatened, and some are at risk of disappearing in Wales. The project will use long term nature-based solutions to improve the ecological quality of the four rivers such as, improving accessibility for migratory fish, improving habitat structure and function, and improving water quality.

Working with partner organisations, farmers, landowners, local communities and contractors the project aims to:

- Improve conditions for salmon, lamprey, shad, bullhead and other fish populations that have declined drastically in recent years.
- Remove constraints to fish migration – improve fish passage at 12 sites, addressing in-river barriers such as weirs and other structures.
- Re-naturalise rivers and restore natural processes – boulder, woody material and gravel re-introduction. Re-meandering, and floodplain reconnection along 5km of river and restoration of freshwater and wetland habitats on 136 hectares of floodplain. (*This aspect of the project is described in more detail in the below Case Study*).
- Planting 50,000 native trees (supplied by the Woodland Trust) along river banks to create habitat, increase shading and establish buffer strips with 100km of fencing, with associated water quality and bank stability benefits.
- Reduce the impact of invasive non-native species such as Himalayan balsam, American skunk cabbage, Japanese knotweed and giant hogweed. Trialling Rust Fungus on 8 sites to reduce Himalayan balsam, and working with contractors and volunteers to significantly reduce coverage in 15 sub-catchments.
- Improve land management practices – reducing nutrients and sediment inputs from

agricultural land by working with farmers and landowners to promote best practice farming techniques with the aim of engaging 350 farms.

- Habitat improvement over 15km for the critically endangered Freshwater Pearl Mussel.

The project will work closely with the River Restoration Centre (RRC – an Associated Beneficiary), and the European River Restoration Centre (ECRR) across Europe, in order to facilitate knowledge transfer and dissemination from the project. The project is led by Natural Resources Wales in partnership with the Brecon Beacons National Park Authority, River Restoration Centre, Agricultural Research Centre Coleg Sir Gâr and Woodland Trust. The project was established in 2021 and is planned for completion in December 2026. Funding totalling £9 million for the Four Rivers for LIFE Project has been given to Natural Resources Wales from an EU LIFE programme grant, with support from Welsh Government and Dŵr Cymru/Welsh Water (LIFE20/NAT/UK/000100).

Case study: Re-establishing natural processes by introducing large wood into the Tarell River, part of the Usk River SAC

Tarell River (Usk River SAC)	High energy, gravel/cobble/boulder
Location	Libanus, Powys, Wales, UK
WFD mitigation measure	N/A
Waterbody ID	GB109056033070
Designation	SAC
Project specific monitoring	Morphology, substrate transport/characteristics, fish, macroinvertebrates.
Date of works	Autumn 2024
Length	600 metres
Cost	£18,000

The Tarell River is a high energy, predominantly gravel, cobble, boulder-bed stream, which runs for approximately 13km from its source in the Brecon Beacons to its confluence with the Usk River near Brecon. Much of the upper part of the Tarell River catchment is under National Trust ownership as the river flows through land owned by the orgnaistaion at Ty Mawr Farm.

Ty Mawr Farm, at the heart of the Bannau Brycheiniog National Park, is on a journey to re-naturalise the land from agricultural use to one connected to its natural environment and surroundings. The National Trust have expressed an ambition of using Ty Mawr Farm to demonstrate what can be achieved for nature whilst still farming productively. This approach ties in with their new 10 year strategy, People and Nature Thriving, which sets out an increased focus on tackling the nature crisis, on its own land and through partnership working. After a previous farming tenancy expired in December 2023, the National Trust took back management of the site with the aim of reducing agricultural pressures and restoring conservation management to much of the valley.

Background

Intensive management of the thin margin of riparian woodland and flood maintenance activities have left the river depleted of dead wood and lacking habitat diversity. The lack of instream wood and associated dynamism meant much of the gravel substrate had become stable and consolidated, reducing suitability for fish spawning.

Gravel supply in this catchment is also limited by road infrastructure associated with A470. A dense single line of trees along both banks limited lateral mobility of the channel, which had become incised and disconnected from its floodplain. There were also artificial embankments present, which further reduced floodplain connectivity.

In collaboration with the River Restoration Centre, Natural Resources Wales's Four Rivers for LIFE project produced a river restoration plan. The aims of this plan was to improve river habitat by substantially increasing the amount of in-channel large wood to reestablish natural processes, raise bed levels and improve lateral connectivity. Embankment removal was also recommended aimed to increase floodplain inundation rates with floodplain habitat and flood benefits.

Design

The works targeted a stretch of the Tarell where there was a relatively low area of floodplain on the left hand bank (LHB) and agricultural land on the right hand bank (RHB) was protected by a natural river terrace (Figure 1). Fourteen large wood structures were placed every 30-50metres (approx. 5-7 river widths) at locations where they would have the greatest habitat benefits and maximised chances of out of bank flow on LHB.

Due to potential flood risk downstream, the large wood structures were designed to be immobile. Riparian trees at least two times river width in length were selected. Trees were winched over with root plates attached (Figure 2) and were keyed into other live bankside trees to minimise the chances of them being mobilised during large floods. No tethers, anchors or other artificial methods of fixing trees were used. 'Chop and drop' was undertaken further upstream to provide further structure as the finer material catches on the larger less mobile structures.

Figure 1
River restoration plan for River Tarell

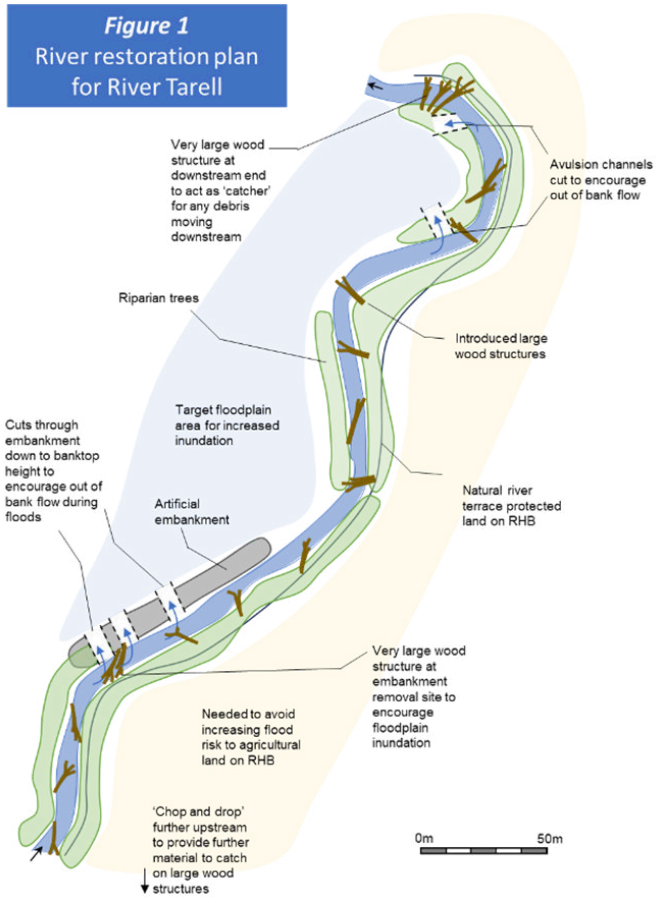
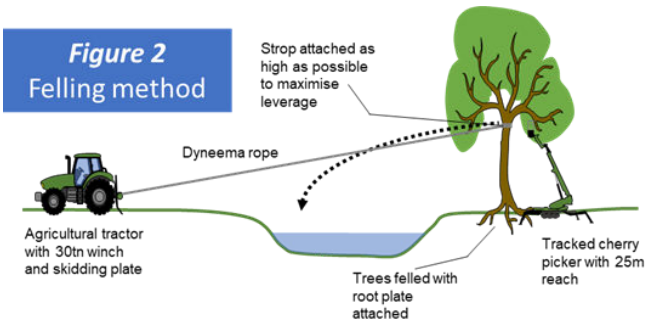


Figure 2
Felling method



In addition to the large wood structures, several cuts were made in the artificial embankment to encourage floodplain inundation during high flows. Two avulsion channels were also created towards the downstream end of the floodplain to encourage the formation of secondary flow channels.

FIGURE 3 *Example of newly created large wood structure. © NRW*

FIGURE 4 *Embankment removal and large wood structure behind. © NRW*

Lessons learnt

- Check valley cross sectional profile first – only suitable if flood risk to property is low.
- Utilise on-site trees wherever possible.
- Go big – need large trees in high energy environments.
- Winching over is safer than pushing with excavator.
- Don't worry too much about exact placement – wood structures will settle into place.
- Get as much structure of the trees in contact with bed as possible.
- Avoid fixing (wire, anchors etc.) if possible.
- Ensure you have competent and experienced contractors.

After **only three months** the benefits of the restoration scheme was evident. Localised areas of erosion and deposition are starting to appear around the large wood structures. Newly worked areas of gravel have appeared, directly associated with the introduction of the wood. Several high flow events have happened since the works in Autumn 2024 and large areas of the floodplain have been inundated with water where they would not have been pre-works. There is also evidence of some secondary channels starting to form at the avulsion channels.

Despite some fairly extreme wet weather events (Storm Bert and Storm Darragh), no flooding has been caused to agricultural land on RHB and none of the large wood structures have moved significantly.

FIGURE 5 *New mid-channel gravel bar created downstream of a large wood structure. © NRW*

Monitoring & Future work

Monitoring the pre-works and post-works condition of the stretch has been captured using RHS and Morph surveys, electrofishing surveys, macroinvertebrate sampling and REDOX testing to assess interstitial flow through gravels. The large wood structures have been fitted with PIT tags and movements will be monitored. Drone footage and trail cams are also being used to monitor changes.

Future work:

- Phase 2 is planned for late summer 2025.
- Monitoring of the site will continue until the end of the Four Rivers for LIFE project in December 2026.

FIGURE 6 *Post-works floodplain inundation during high flows. © NRW*

For more information: Natural Resources Wales / Four Rivers for LIFE, or to contact a member of the team 4RiversforLIFE@naturalresourceswales.gov.uk.

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Cyfoeth Naturiol Cymru Natural Resources Wales

Co-funded by the European Union

LIFE Dee River project

LIFEDeeRiver is a major large-scale project to transform the River Dee and its catchment by restoring the river and surroundings back to its natural state. This will bring many benefits to the environment, most notably improving the numbers of salmon, lamprey and freshwater pearl mussels to help them become more sustainable in future.

Erbistock weir

The Dee is a Special Area of Conservation (SAC) with Atlantic salmon an Annex II species that are a primary reason for selection of the site. One of the flagship projects of the LIFEDeeRiver was to be the removal of Erbistock weir as it is the first major barrier on the non-tidal section of the river Dee for Atlantic salmon (*Salmo salar*), sea lamprey (*Petromyzon marinus*), European bullhead (*Cottus gobio*), river lamprey (*Lampetra fluviatilis*) and brook lamprey (*Lampetra planeri*).

Erbistock weir is approximately 80m wide, stone built and set at an angle to the flow circa 46km from the tidal limit. A baulk fish pass was located on the right bank which is in a bad state of repair and is only suitable for a limited range of species (mainly salmonids) at certain flows. This can be seen in figure 2. Removal of the weir would open up approximately 88km of main stem river for all fish species.

There was an area of damage to the glacis of the weir, which made fish passage more challenging, due to competing attraction flows. The removal location was dictated, to a degree, by the location of this damage.

FIGURE 1 *View of Erbistock Mill across the weir in high flow - September 2023 © RRC*

FIGURE 2 *Side view of section to be removed taken from lefthand bank till current damage to weir face. © LIFEDeeRiver*

FIGURE 3 *Location map of Erbistock Weir near Wrexham, Wales. © LIFEDeeRiver*

Current issues

Through acoustic tracking studies, the LIFEDee-River project demonstrated that Erbistock weir was a partial barrier to *Salmo salar*, *Petromyzon marinus* and *Lampetra fluviatilis* (figures 4 and 5). On the graphs, the red dots indicate detections picked up on a receiver (receivers denoted as a yellow triangle on the Y axis). The solid black line indicates Erbistock weir.

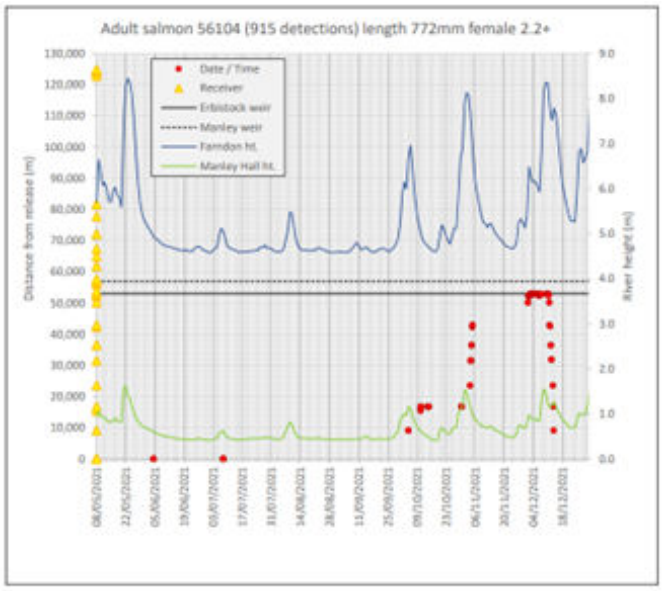

FIGURE 4 *Acoustic track of adult salmon that failed to pass Erbistock weir. © LIFEDeeRiver*

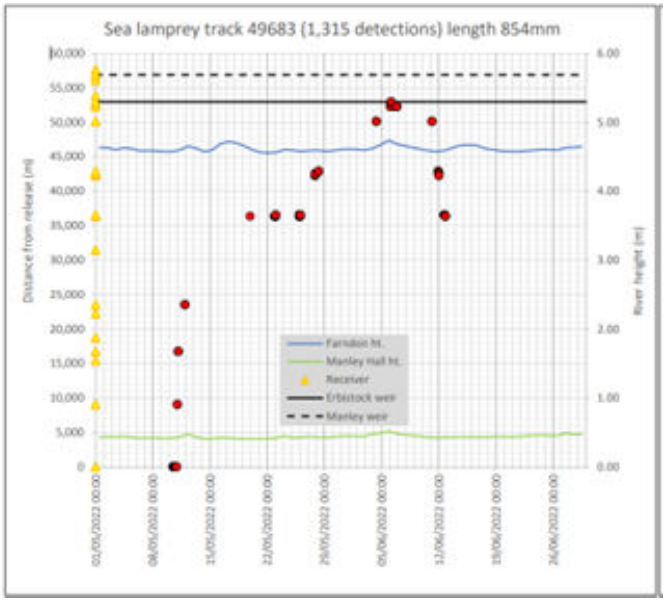

FIGURE 5 *Acoustic track of adult sea lamprey that failed to pass Erbistock weir. © LIFEDeeRiver*

Planning and funding

The project is generously supported by the European Union LIFE+ Nature and Biodiversity Programme, as well as Natural Resources Wales, Welsh Government, Dwr Cymru/Welsh Water, Eryri National Parc, and the River Restoration Centre.

All management of the project was done within the dedicated LIFEDeeRiver project team, with assistance from colleagues both within and outside Natural Resources Wales.

The final cost for the removal of Erbistock weir was just over £500,000, which offered a saving of around 30% on the initial quote, through savings made by the contractor. The removal has ensured that passage for all fish species (not just the SAC features) is now unhindered for the first time in nearly 200 years.

Proposal

The proposal was to remove approximately 40m of the weir to create a new primary flow channel. This will mimic the natural width of the river in the area to imitate the natural morphology present to encourage natural processes to re-establish. All stone removed from the site was redistributed within the channel, either to provide protection for the remaining weir, or as habitat creation.

FIGURE 6 *200 m above the removed Erbstock weir. Bars and islands can be seen here at low flow as river gravel becomes mobile again – September 2024 © RRC*

Detailed flow and flood flow assessments were made prior to securing all required permissions. As the structure had no current impoundment licence, this had to be granted to allow removal to be carried out, as well as HRA assessment, Flood Risk Activity Permits, planning permission and European Protected species licences.

FIGURE 7 *View of the removed weir and free flowing river the end stages of completion © LIFEDeeRiver*

Heritage

The weir in its current form was of an unknown age, with records of a structure at the site dating back to the 11th Century. Through discussions with Cadw and Heneb there was a requirement to carry out a level 2/3 survey on the site (Historic Building Recording - Heneb). It was recognised that the site was previously listed with the Mill building, but this listing had been removed following work to the mill building in the 1990's.

Heneb archaeologists carried out a level 2 survey in 2023, covering the landscape and setting of the features (mill building and weir). During the removal of the weir a periodic watching brief was carried out by archaeologists from Heneb, which allowed them to record the construction materials, artifacts and fully document the weir. This link with heritage has ensured that we have all learnt more about the construction of the weir, protecting history and ensuring the records are available to the public.

FIGURE 8 *Some of the long diagonal weir was retained to help protect the mill September 2024 © RRC*

Delivery

Work on site was carried out by a local contractor (S E Metcalfe a'i Gwmni Cyf) over an 11 week period in 2024. Flows during this period remained low for much of the time, with work on the weir only halted for 1½ days due to high flows. Access was created to the weir from the right bank, where a compound area was created, and machinery were able to track on the top of the weir crest to access both banks.

Dry working areas were created on both banks using dumpy bags filled with river gravel. Once work was completed, these bags were simply slit and the gravel introduced to the system. All stone material remained on site, with metalwork found within the old weir removed and recycled. The work was completed without any H&S incident. Several impromptu rescue drills were carried out during the works, with all staff on site at the time working well.

There was one minor environmental incident when a hydraulic hose on one of the machines split. A small amount of biodegradable oil ent-

ered the watercourse, but the machine operator deployed the correct spill kit and all oil was contained and removed within minutes, leaving no impact to the environment.

Results

During work contractors spotted sea trout passing the site, indicating that the removal would be effective. In May 2025, a sea lamprey redd was spotted by LIFEDeeRiver officers upstream of where Erbistock weir had been, indicating that sea lamprey had successfully migrated past the structure that previously been a significant challenge to them.

Further monitoring will be carried out using drones on pre-programmed flight paths. These drone surveys will be used to monitor the changes in the upstream and downstream changes to the river channel. Initial results are shown in figure 9.

Lessons learnt

- Early contractor involvement is key to successful delivery of works of this scale. By engagement with the successful contractor, fewer trees had to be removed than planned, and the access into the river was much simpler (and therefore less costly) than anticipated.
- When working in high water volume environments, it is important that the safety of the contractors is recognised. We had a dedicated rescue team on site for 8 weeks through the most high risk part of the contract.

For more information: Natural Resources Wales / LIFE Dee River, or to contact a member of the team lifedeeriver@cyfoethnaturiolcymru.gov.uk.

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FIGURE 9 *Orthorectified image of the post removal area above Erbistock works 4 November 2024.*
© LIFEDeeRiver

LIFEConnects

Länsstyrelsen Skåne

Connecting people and rivers for sustainable free flowing rivers

The LIFE CONNECTS project takes actions to improve ecosystem functions and ecosystem services in seven rivers in southern Sweden benefiting humans, biodiversity and sustainable water use. We achieve this by improving connectivity through the removal of barriers, the creation of fish passages, and the restoration of degraded river habitats. Around 600 km of river in 7 catchment areas will be improved. The rivers support several species and their habitats. Target species are Atlantic salmon and two of the most threatened mussel species in Europe; freshwater pearl mussel and thick-shelled river mussel.

Description

Together with partner organisations, farmers, landowners, local communities and contractors' best practice are used to ensure the right river restoration measures at the right place. Around 600 km of river in 7 catchment areas will be improved. The project work closely with the European Centre of River Restoration (ECRR) and other organizations across Europe, to facilitate knowledge transfer and dissemination from the project.

FIGURE 1 *Map over the seven river catchments in LIFE CONNECTS.*

The project is led by the County Board of Scania in partnership with the County Board of Kalmar, the Swedish Agency for Marine and water management, Klippan municipality, the Swedish angler association, Karlstad University and Uniper. The project was established in 2019 and is planned for completion in 2028.

Funding totalling €8.8 million for the LIFE CONNECTS Project has been funded by EU LIFE Nature programme (LIFE18/NAT/SE/000742), and all partners.

Background

Most rivers in Sweden and across Europe have been altered by humans for a long time by straightening, ditching and damming. As a result, we often find migration barriers that prevent species such as salmon (*Salmo salar*) and sea trout (*Salmo trutta*) from reaching their spawning and rearing areas in the upper parts of the river catchments.

Most rivers have moderate ecological status (classification according to the Water Framework Directive) as a result of human activities such as agriculture, hydropower and historical timber floating. The barriers have not only influenced the migrating fish populations. Mussel species such as freshwater pearl mussels that are dependent on host fish, such as salmon and trout, for its reproduction have declined drastically during the last decades due to the loss of host fish and suitable habitats.

Case study: Connectivity improvements

In Emån (no. 6 in the map) in the county of Kalmar, several barriers have been removed and river habitats restored. The ecosystem functions in the river have been improved by creating free migration possibilities as well as by adding stones, gravel and dead wood to create a more varied bottom structure. This will improve migration opportunities for fish and restore habitats for both fish and mussels. In turn, this contributes to better water quality and more natural free flowing rivers, one of the major goals of the EU Biodiversity Strategy 2030. In Nötån, one of the larger tributaries to Emån, a barrier have been removed to reactivate a large braided river system.

Nötån River	High energy, gravel/cobble/boulder
Location	Kalmar county, Sweden
WFD mitigation measure	Removal of barrier, habitat restoration
Waterbody ID	SE634252-150052
Designation	Nature 2000 area
Project specific monitoring	Fish
Date of works	Autumn 2024/Spring 2025
Length	Open up 14.5 kilometres of river
Cost	Approx. €140 000

By removing the barrier, fig. 2, more than 2 hectares of braided river system was restored and more than 14.5 km of river once more open for fish migration.

This will increase the migration of fish and increase the populations of salmon and trout in the system. This in turn, will benefit the population of the threatened freshwater pearl mussel in the river, as they are dependent on salmon and trout to complete their life cycle. Habitat restoration was planned in parts of the opened braided river area, fig. 4. The aim was to restore the braided river to its former complexity and ecological functions. Since these braided rivers have unique ecosystems, they are important for the biodiversity of the river.

FIGURE 2 *Section of the barrier that was removed and the braided river system downstream was activated again. © Ebbe Berglund*

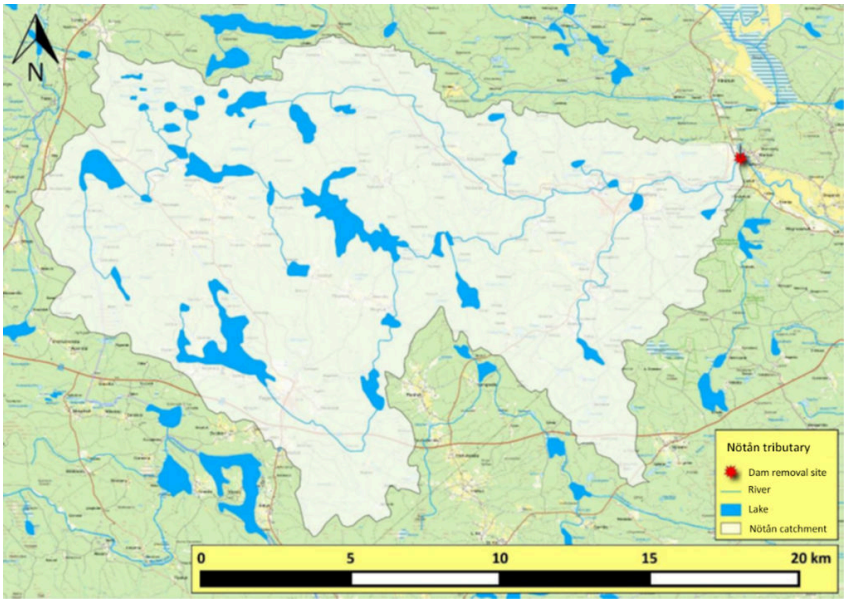

FIGURE 3 *The upper parts of Nötån that has been opened for migrating fish after the barrier removal in Nötån. The red dot indicates the location of the barrier that was removed.*

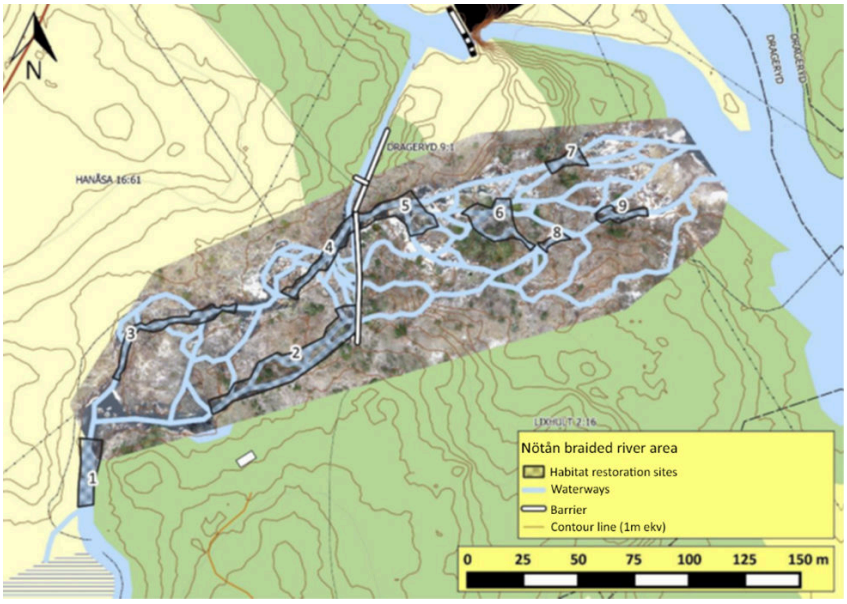

FIGURE 4 *Map over the planned habitat restorations at 9 locations in the opened braided river system.*

Improvements for freshwater pearl mussel

FIGURE 5 *The threatened freshwater pearl mussel can be up to 15 centimetres long and become over 250 years old. © Jakob Bergengren*

The freshwater pearl mussel (*Margaritifera margaritifera*) is present at Nötån, fig. 5. Historically it has been one of the largest populations in Kalmar County. However, over the past century, the mussel species have undergone a significant decline in both distribution and population size, primarily due to barriers, habitat degradation and other anthropogenic impacts. Today, the species is classified as Endangered in Sweden, with fragmented populations and reduced or absent reproduction. The freshwater pearl mussel is an important keystone species in freshwater ecosystems, and provide important ecosystem services such as water purification, sediment mixing and stabilization, benefiting overall biodiversity.

In Nötån the removal of the barrier that opened 14.5 km of river is of great importance for the freshwater pearl mussel population in the river as well as for the whole Emån river system as a whole. Further, in the LIFE CONNECTS project re-introduction of mussels through infestations of host fish with mussel larvae has been conducted to enhance the reproduction in three of the project rivers.

Monitoring and lessons learnt

Electrofishing is a common scientific survey method and fishing technique used to monitor fish populations to determine abundance, population density and species composition before and after restoration measures. When performed correctly, electrofishing is not harmful to the fish.

The lessons learnt are as follows:

- Early dialog with stakeholders is essential for achieving sustainable restoration measures.
- Holistic approach – remove barrier and restore habitat to gain effects on ecosystem functions and for several species at the same time.
- Ensure you have competent and experienced contractors.

The project started in 2019 and with a budget of 8.8 million euro LIFE CONNECTS will open up around 600 kilometres of river and restore around 100 hectares of river habitat that will improve the conservation status for habitats and species. Hence, river restorations will bring back sustainable ecosystems that can provide ecosystem services for nature and people.

FIGURE 6 *Monitoring of pre- and post-restoration conditions has been conducted using electrofishing surveys, and drone footage. © Ebbe Berglund*

Life cycle of the freshwater pearl mussel (*Margaritifera margaritifera*)

The complex life cycle of freshwater pearl mussel. During the breeding season, females lay eggs and brood them inside specialized chambers in their gills. Males release sperm into the open water, which is then drawn into the females through their siphons. The sperm fertilizes the eggs. Inside the female mussel, fertilized eggs develop into microscopic larvae known as glochidia. The female release 1 to 4 million glochidia in July-August into the water where they must come into contact with the appropriate fish host, i.e. salmon or trout, as it swims by. Once in contact with the right host fish they must attach to the gills or the fins and encyst to complete development. Metamorphosis takes place within approximately 9 months during which the glochidia transform into microscopic juveniles and drop off. If by chance they settle into suitable habitat, the juveniles stay fully buried within the riverbed for at least 5 years. At the age of 12 they are mature and able to contribute to the reproduction of new mussels.

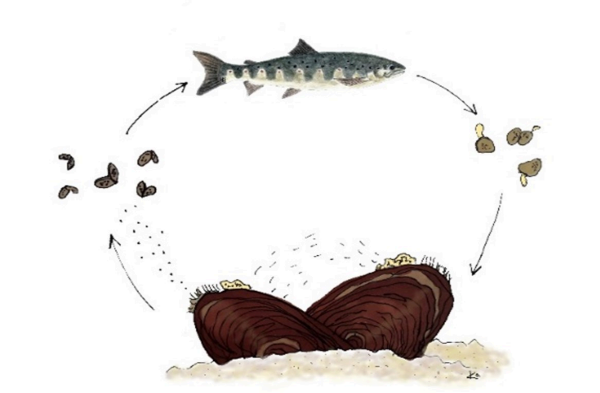

FIGURE 7 *The freshwater pearl mussel is dependent on salmon and trout as host fish. Illustration: Karin Olsson*

Find out more about the project on www.lifeconnects.se and social media.

Views and opinions expressed in the article are those of the author only and do not necessarily reflect those of the European Union or the beneficiaries of the project. Neither the European Union nor the beneficiaries can be held responsible for them.

Improve Aquatic LIFE

Länsstyrelsen Skåne

Co-funded by the European Union

Improving aquatic ecosystems from source to sea

The project started in 2024 and Improve Aquatic LIFE will implement over 300 restoration measures in 20 river catchment areas and 3 coastal areas in southern Sweden. This will benefit humans, biodiversity and sustainable water use. Further, the project will improve the conservation status for habitats (nature types according to EU Habitats directive) and species. Hence, restorations from source to sea will improve the resilience of water ecosystems that will provide ecosystem services for nature and people now and for future generations.

Description

The Improve Aquatic LIFE project takes actions to improve aquatic ecosystem functions and ecosystem services from source to sea in two water districts in southern Sweden, fig. 1. The project achieve this by improving connectivity through the removal of barriers, the creation of fish passages, and the restoration of degraded river, lake and coastal water habitats as well as improving hydrology and resilience by restoring wetland.

Together with partner organisations, farmers, landowners, local communities and contractors a holistic approach and best practice from source to sea are used to improve the status of our waters. The project work closely with the European Centre for River Restoration (ECRR) and other organisations across Europe, in order to facilitate knowledge transfer and dissemination from the project.

The project is led by the County Board of Skåne in partnership with the eight other county boards in Southern Sweden, two municipalities, the Swedish Agency for Marine and water management, the Swedish Environmental Protection Agency, three universities and the Swedish angler association. The project was established in 2024 and is planned for completion in 2031.

Funding totalling €34 million, the Improve Aquatic LIFE project has been funded by EU LIFE Nature programme (LIFE23/NAT/SE/101148230), and all partners.

Background and holistic approach

Most aquatic ecosystems in Sweden and across Europe have been significantly altered by human activities for a long time by river straightening, ditching and damming. As a result, many rivers often contain migration barriers that prevent species such as Atlantic salmon (*Salmo*

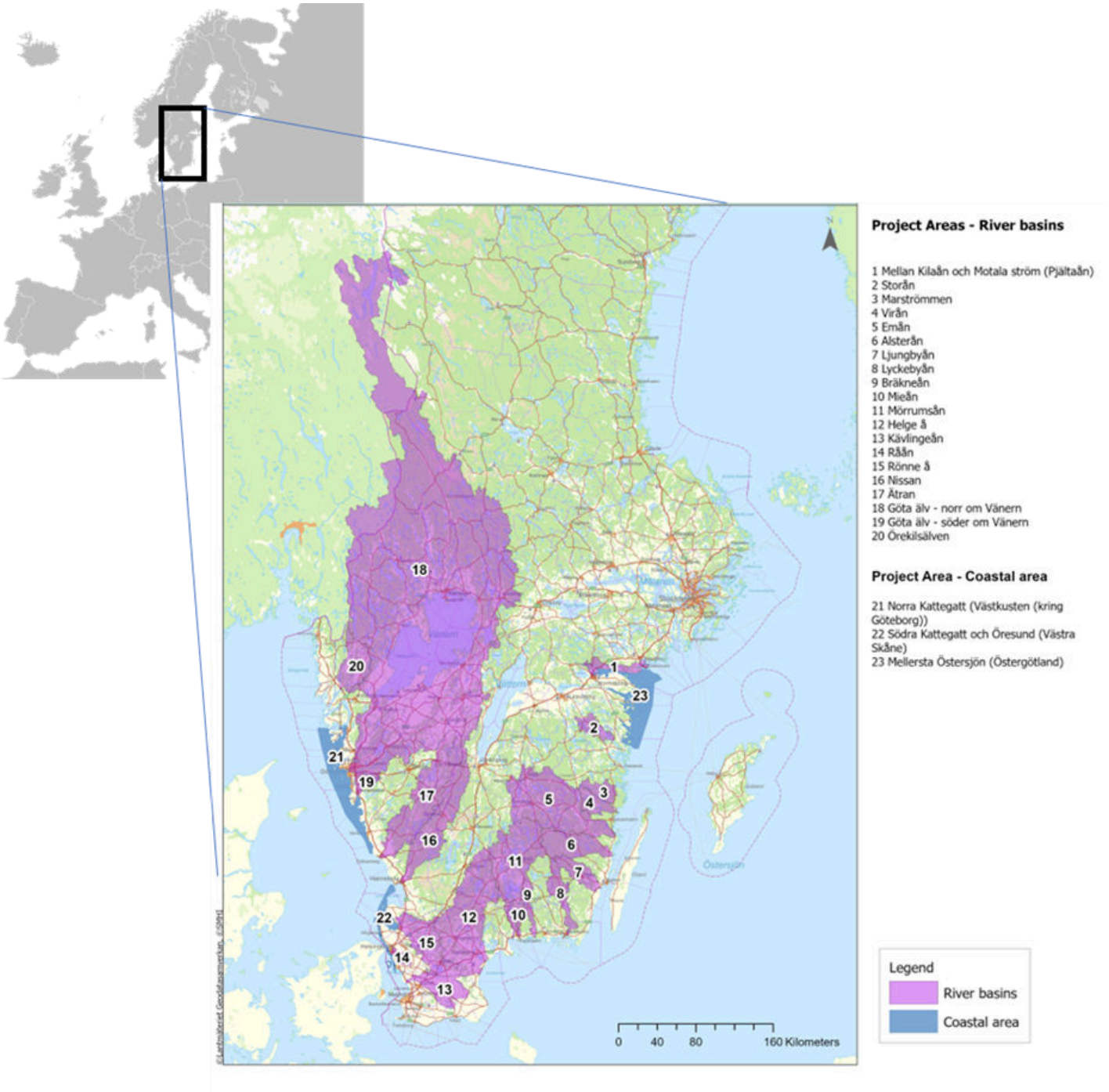

FIGURE 1 *Map over the Improve Aquatic LIFE project areas in Skagerrak and Kattegat Water District and South Baltic Sea Water District in southern Sweden.*

salar) and sea trout (*Salmo trutta*) from reaching their spawning and rearing areas in the upper parts of the river catchments. Most rivers have moderate ecological status (classification according to the EU Water Framework Directive, WFD and Marine Strategy Framework Directive, MSFD) as a result of human activities such as agriculture, hydropower and historical timber floating. Also, many lake-, wetland- and coastal water ecosystems have been altered to benefit agriculture, forestry, shipping and industry. To improve the ecological status (according to EU WFD) or conservation status (according to the EU Habitats directive and Prioritised Action Framework, (PAF) for Natura 2000 in Sweden) as well as reaching the goals of the EU Biodiversity strategy for 2030, restoration measures are needed in many aquatic systems in southern Sweden.

The journey towards improved water ecosystems begins with a thorough investigation of the river catchments from their sources all the way to coastal waters. Understanding the current status and identifying the environmental impacts affecting the status are crucial information for determining what measures gives the highest impact and to prioritizing the restoration actions accordingly. In one catchment area, the most effective measure may be to improve longitudinal connectivity by removing migration barriers. In another, restoring the natural hydrological regime through wetland restoration may be of greater importance. By using a holistic approach looking at the whole catchment and all environmental problems present the most effective restoration measures can be applied. The holistic approach combines the different goals of EU directives and strategies, and the different types of restoration measures needed to improve ecological- and conservation status through improved connectivity, hydrology and habitats, fig. 2.

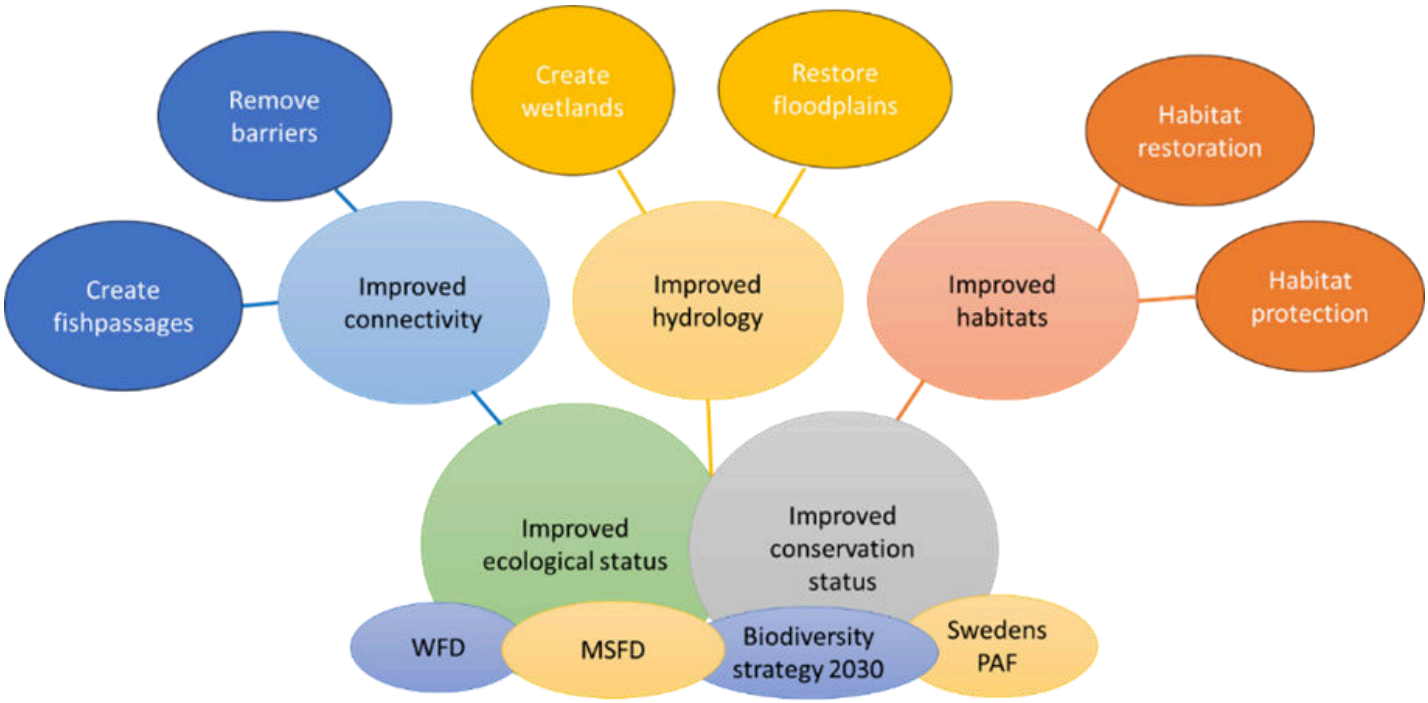

FIGURE 2 *By using a holistic approach several EU directives and strategies can be targeted within the project.*

Theme 1 – Connectivity

- Longitudinal connectivity
  - Barrier removal
- Lateral connectivity
  - Restore floodplains

Theme 2 – Morphology

- Rivers
  - Restore riffles and pools
  - Remeandering
- Coastal waters
  - Restore stone reefs

Theme 3 – Hydrology

- Wetland
  - Restore wetland
  - Re-wetting of mires and bogs
  - Plugging ditches in forest
- Lakes
  - Restore lowered lakes

Theme 4 – Species

- Mussels
  - Infestation of host fish
  - Restore habitats
- Eelgrass
  - Planting of eelgrass

FIGURE 3 *The four themes and restoration measures that Improve Aquatic LIFE project will work with.*

Themes, Habitat types and Species

To improve connectivity, hydrology and habitats in rivers, lakes, wetland and coastal areas it is important to focus on a couple of themes. Trying to grasp everything at once will make a project scattered, making it difficult to monitor the effects of restoration measures and to evaluate if the aim of the project is fulfilled. Improve Aquatic LIFE works in four different themes, fig. 3. The themes have been chosen according to habitat type and species targeted by the suggested restoration measures.

Atlantic salmon and sea lamprey (*Petromyzon marinus*) are the two targeted fish species in the project and most of the restoration measures that will be done in the project will directly or indirectly benefit these two species. Sea lamprey is a prehistoric fish that has existed for over 400 million years. Today, the survival of the species is strongly threatened and at risk of extinction in Sweden, fig. 4. A national action program works with concrete efforts to improve the situation for Sea lamprey. Increased knowledge and understanding of the species are an important part which the work in the project will contribute to.

FIGURE 4 *A sea lamprey preparing a spawning area by moving stones with their mouth. © Elisabeth Thysell*

Theme 1. Connectivity – longitudinal and lateral restorations

One of the most important restoration measures to improve the Atlantic salmon and sea lamprey populations is connectivity restoration by removing barriers and restoring floodplains to gain both longitudinal and lateral connectivity. Removing barriers, fig. 5, will allow migratory fish species such as salmon and lamprey to reach their spawning and nursery habitats that have been inaccessible for many centuries. However, many spawning and nursery habitats in rivers have been degraded or lost by human activities and needs to be restored at the same time as the barriers are removed to improve the reproduction success of these species.

FIGURE 5 *The first barrier in Råån river, just 3 kilometres from the sea, will be removed. © Ebbe Berglund*

One of the barriers in the Råån river, with no function today, will be removed within the project. By removing the barrier salmon and trout will be able to migrate from the sea to their spawning areas upstream.

Theme 2. Morphology – habitat restorations

To improve the morphology, habitat restoration will be done. Historically, stones were cleared from the rivers to accelerate drainage from agricultural and forestry areas. Today, one major habitat restoration measure is to bring back the stones to the river to recreate natural bed structures and flow conditions.

Along the coast of southern Sweden so called stone fishing, fig. 6, has occurred historically, where stones were removed from the seafloor to build piers and harbours. In these coastal areas it is a quite new restoration method to bring back the stones to the seafloor re-creating stone reefs and thereby restoring lost habitats and promote biodiversity in areas previously impacted by stone fishing.

FIGURE 6 *The most common tool for historical stone fishing was a grabbing tool. © Olle Nordell*

A special tool, see figure 6 was used from boats and often with a diver that placed the "jaws" around the boulder. This type of "stone fishing" was common in western Scania and in Denmark. In Improve Aquatic LIFE, coastal habitats where historical stone fishing is believed to have taken place, will be restored by recreating stone reefs.

Theme 3. Hydrology – restoring natural water regimes

The hydrology of many rivers has been altered over time due to human activities. To gain more agriculture land, wetlands has been drained and forests were ditched to get rid of the wet mires and bogs. Changes in land use and loss of wetland have affected surface runoff, groundwater storage and streamflow and thus altered the hydrology within the watershed areas. These alterations have led to increased floods and droughts in the southern parts of Sweden with impact on food production, infrastructure and society. By restoring wetland, mires and bogs as well as lakes, the project aims to re-establish natural hydrological processes to increase the resilience to climate-related impacts.

Theme 4. Species – specific restoration measures

For some species, such as mussels and plants, that do not migrate or move longer distances, habitat restoration alone is not enough. For these species, additional restoration measures are needed. Improve Aquatic LIFE will therefore strengthen the threatened mussel populations of freshwater pearl mussel (*Margaritifera margaritifera*) and thick-shelled river mussel (*Unio crassus*) by infestation of host fish with mussel larvae (i.e. glochidia) in nine of the project rivers.

In the coastal waters of southern Sweden, the important plant eelgrass has declined or gone extinct in many places. Eelgrass meadows are unique and among the most productive ecosystems in the world. They provide important habitats for many species and are vital nurseries for fish and provide habitats and food for a diversity of marine life. In the Improve Aquatic LIFE project, eelgrass will be planted by scuba divers, fig. 7, on at least 4 hectares.

FIGURE 7 *A scuba diver planting eelgrass at the seafloor. © Eduardo Infantes*

Best practice and engagement

Successful restoration of aquatic ecosystems requires the use of best practice and a close collaboration with academia to ensure that the latest knowledge about best practice for restoration of different types of aquatic ecosystems are incorporated in the project. Engaging stakeholders is also crucial to implement the right restoration measure at the right place to get the best effects possible.

Three of the universities in Sweden are partners in the project to ensure that best practices are used. They will keep the project up to date with the latest findings in research and by monitoring the effects of the implementations of restoration measures, fig. 8.

Electrofishing is also used to catch salmon and trout for marking to be able to track migration patterns by acoustic telemetry systems before and after restoration measures.

One important part of a LIFE project is to raise awareness and improve knowledge about aquatic ecosystems and why restoration is important. By engaging stakeholders in restoration activities and arrange information activit-

ies, such as walk and talks, school activities and give talks the partners of Improve Aquatic LIFE will contribute to a better understanding of the restorations done in the project and transfer knowledge and experiences to facilitate future restoration projects.

FIGURE 8 *One of the monitoring methods is boat electrofishing in deeper waters. © Karin Olsson*

Expected improvements and challenges

Free flowing rivers	300 km
Re-wetting	700 hectar
Introduction of mussels	500 000 juveniles
Planting eelgrass	4 hectar
Creating stonereefs	0.3 hectar
Restored wetlands	40 hectar
Restored lowered lakes	3 lakes
Removed barriers	96 barriers
River habitat restored	130 hectar

Through the restoration measures implemented in the project several kilometres of rivers and hectares of water habitat types will be improved. Further, several species will benefit from the restorations measures due to improved water quality, more natural hydrological regime and habitats.

Improve Aquatic LIFE has 17 partners and collaborates with several stakeholders when implementing the restoration measures. It requires a robust organisation and extensive communication for the project implementation to function well and everyone working towards a common goal. Other challenges for the project are:

- Permit and licences processes – often takes a lot of time and resources.
- Conflicting interests – for example the removal of a barrier at an old mill of cultural historical values to benefit fish migration and other nature values.
- Public and political opinion may change – so it gets harder to find funding for or implement the restoration measures.

Find out more about the project on www.improveaquaticlife.se and social media.

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