River restoration in the Baltic Sea region: best practices and recommendations for successful projects

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Executive summary

There is global concern of the status of rivers and the freshwater biodiversity they support. Also, in the Baltic Sea region coastal rivers are heavily affected by human-caused pressures, leading to deteriorations of ecosystems and species dependent on these habitats. The long neglect on rivers has degraded many of the original migratory fish populations. For instance, of the numerous original sea trout (*Salmo trutta*) populations many have been lost and of the existing ones a large part needs urgent recovery from the negative effects of habitat degradation, migration barriers, and fishing.

To act for improving the poor condition of rivers and their migratory fish, restoration is a sustainable solution. River restoration entails a large selection of ecological, physical, spatial and management measures and practices for re-establishing the natural state and functioning of a river system. As there is an increasing interest and societal demand – but often limited resources – for the recovery and restoration of rivers and migratory fish populations in the Baltic Sea region, the importance of a well-informed choice of restoration projects and sound practices for carrying out them is highlighted. Successful river restoration requires knowledge about relevant hydro-morphological, ecological, social/cultural, economic, and legal as well as policy aspects.

For the Baltic Sea region, with its shared environment and resources, similar geo-climate, and joint commitments, it is conducive to jointly identify, compile and disseminate practices that lead to successful river restoration projects. This has been done by the EU Interreg project RETROUT that through a number of thematic activities have gained useful experiences and gathered knowledge on Baltic Sea sea trout rivers and river restoration. As one step towards better river restoration projects RETROUT has compiled this Baltic Sea river restoration best practices guidelines report. These practices broadly cover aspects related to project prerequisites, realisation and feasibility, sustainability, and essentially to impact and effectiveness ultimately for improving migratory fish populations.

This report presents a background overview, summary results and developed bast practices and recommendation for successful river restoration projects in the Baltic Sea region. The report focuses on river restorations with primary objectives to improve migratory fish populations, especially sea trout. The purpose of this report lies in its region-specificity and scope, striving to describe the best practises for the entire river restoration project process, from initial identification of the problem to the phase of impact and success evaluation. This report and the river restoration best practices are built upon on the outcomes dedicated RETROUT project activities, including a study evaluating factors of success and failure from past restoration projects, and a number of concrete river restoration projects conducted in course of the RETROUT project. The evaluation study on river restoration success factors was based on data from nearly 100 past river restoration projects in the Baltic Sea region. The concrete RETROUT river restoration projects contained 16 cases in the project partner countries, comprising fish ways installations, habitat restorations, water quality improvement, and dam removal plans.

In summarising the main outcome form the evaluation study on river restoration success factors, the report presented important specific lessons learned for project success, concerning inter alia proper design of fish way solutions, use of a comprehensive project approach, careful choice of actions and targets as well as monitoring and project evaluation, and maintenance of good water quality. Factors thwarting achievement of restoration goals were wrong technical design and implementation, and conflicts of interests among stakeholders. An in-depth comparative case study analysis of the success factors showed that the ecological challenges in the river need to be comprehensively acknowledged and understood, and that long-term political support, adequacy and long-term

availability of funds, efficient project team and teamwork, and importantly, successful stakeholder involvement and consensus building, are all centrally important factors for project success.

In the summary of the concrete restoration cases, the report highlighted a number of different lessons learned concerning both technical aspects and general project process matters. The technical type of lessons learned included, e.g., the prioritisation of different solutions for securing fish migration (1. full removal of obstacles, 2. natural-like fish pass, 3. technical fish pass), and preference of habitat restorations towards high structural complexity of the river through strategic addition of gravel, stones, boulders and logs. Regarding the project process factors, several important aspects emerged, including, e.g., the benefit from active involvement of concerned public authorities (State, County, Municipality) and early and continued stakeholder involvement and active conflict solving.

The report then presents best practices for river restoration projects synthesised from gained knowledge and experience of the project activities. Key messages and lessons learned feeding into the best practices, related to matters like ecological knowledge and problem identification, important societal and project specific conditions affecting restorations, project team, stakeholder management, choice and prioritisation of restoration solution and measure, monitoring and project evaluation, for instance. The best practices are presented in a successive manner for a generic river restoration project process. They describe important settings and actions for all five project phases highlighting key aspects that promote successfulness of the project. Practical examples, technical details or other specific information particularly concerning Baltic Sea region sea trout river restorations are provided. Based on the best practices, the key messages are extracted and presented as recommendations for river restoration projects in the Baltic Sea region.

The following general recommendations are given in the spirit of the HELCOM Recommendation 32-33/1:

- Action for the recovery of naturally reproducing salmonid populations needs to be taken.
- Original strains as well as weak and threatened salmonid populations should be prioritised.
- Free passage for fish through the rivers should be provided.
- River waters and habitats should be restored towards *a salmonid habitat in good state* (HELCOM Rec. 32-33/1) when justified.
- A natural life cycle of salmonids should be ensured, and restoration actions to enable natural reproduction and self-sustaining populations are to be preferred before fish stocking.
- Fishing rules and management practices of river fisheries need to support the above-mentioned recovery actions.

A summary list of the Recommendations for successful river restoration projects especially for sea trout rivers in the Baltic Sea region is given below.

Summary list of Recommendations for Baltic Sea river restoration projects

1. A successful restoration project is recommended to thoroughly follow order, tasks and duties of the sequential 5 phases of the restoration project process.
2. A well-managed and coordinated cohesive project team is needed.
3. Rivers and locations for restoration need to be selected carefully based on informed criteria.
4. A restoration process must be preceded by obtaining of sufficient knowledge on the current condition and settings of the river to be restored.
5. Understanding stakeholder's stakes and organising their engagement is critical for the success of the project.
6. Adequacy of funds and other resources on a long-term basis needs to be secured before the project can start.
7. Restoration measures should be chosen based on their expected utility for the ecological objective relative to the costs, within the possibilities set by resources and legal and practical limitations.
8. Planning and design of the project need to be done with great care, and these must be preceded by sufficient preparatory work.
9. Implementation of the restoration plans and designing needs to be correct and effective.
10. The post-implementation processes of monitoring and evaluation need to be carried out for determining the project success and to enable adaptive management of the river.

This river restorations best practices report is aimed at practitioners and authorities involved in river restorations. The best practices and recommendations will support local, regional, and national public authorities of concern on developing conservation and management of migratory fish through river restorations. Additionally, the outcome of this report can serve the macro-regional level by providing input for policy recommendations at HELCOM and EU levels.

1 Introduction

Rivers, streams, brooks, and all sorts of flowing waters carry freshwater from land and lakes to the sea. In constantly doing so these waters constitute special ecosystems and provide essential habitats for numerous organisms. Thus, rivers in good condition support rich biodiversity and provide many essential ecosystem services to society, such as food production, flood control and recreation (Grizzetti et al. 2019, Reid et al. 2019). Flowing freshwaters and their biodiversity are a valuable natural resource worth of and in the need for effective conservation and management (Dudgeon et al. 2006).

Sadly, the negative impact from human activities on river environments is undisputable. Dams and other constructions, habitat deterioration and destruction, as well as pollution and eutrophication have deteriorated numerous rivers globally (Carpenter et al. 2011, Grill et al. 2019, Reid et al. 2019). Less than 40% of the world's large rivers remain free flowing, more than one million migration barriers are estimated to fragment rivers in Europe (Belletti et al. 2020), and the situation around the Baltic Sea is likewise poor (Grizetti et al. 2017). Consequently, the declines of biodiversity in rivers and other fresh waters are far greater than those in marine or terrestrial ecosystems (Dudgeon et al. 2006, Reid et al. 2019). Negative effects are seen across a wide range of taxa with risk for ecosystem-level changes through trophic interactions (Reid et al. 2019).

Many migratory fish species depend on flowing freshwater during at least some part of their life cycle. Migratory fishes might use rivers, streams and brooks as spawning and nursery habitats before they descend to the sea (anadromous), or conversely spend most of their lifetime in fluvial waters to migrate down-streams to the sea for reproduction (catadromous). In either way, accessible and healthy rivers are vital for migratory fish species. As these species migrate between rivers and the sea, they play a very important ecological role in connecting riverine and marine ecosystems. Also, many of these fish are socio-economically important, for example, for food provisioning, recreation and tourism (Lynch et al. 2016, Ignatius and Haapasaari 2018).

Contrasted to other fish, migratory fish are disproportionally threatened on a global scale (Darwall and Freyhof 2016). Critically dependent on river environments in good conditions, freshwater migratory fish species world-wide are facing immense challenges for their persistence due to the destructive human impact on river waters (Dudgeon et al. 2006, Lin et al. 2018). When access to or conditions in these essential river habitats are hampered, the dependent fish populations will suffer, sometimes to the extent of extinction (Collen et al. 2014). Globally, abundance of river-dependent migratory fish has declined by over 75% over the past half a century, and in Europe only (93%), the declines have been even more pronounced (Deinet et al. 2020). During the same period, migratory fish populations with any identified threats along their migration routes have declined in average by 94%, with negative river habitat-related issues (including loss and degradation as well as effects of migration barriers) and overexploitation being the most- and second-most important threats (Deinet et al. 2020).

In the Baltic Sea region, the overall condition of both the sea and its coastal rivers have deteriorated from their pristine conditions due to human-caused pressures on land, in rivers and in the sea. The long neglect on rivers and their fish has destroyed or degraded most of the original anadromous salmonid and other migratory fish populations. For instance, eel (*Anguilla anguilla*) is evaluated as critically endangered, and salmon (*Salmo salar*) and sea trout (*Salmo trutta*) – two iconic migratory species – both as vulnerable (HELCOM 2013). Of these, sea trout has historically been a common species in most of the numerous rivers and streams of the Baltic Sea region, while recently only around 500 natural populations are estimated to exist of which a large part is in urgent need of recovery measures (HELCOM 2011).

In addition to the negative ecological consequences, the losses of fish, such as the sea trout in the Baltic Sea, also reduce the possibility to sustainably use these species as resources by fisheries. To improve the situation, efficient, effective and well-targeted actions are needed. Free and natural access to spawning and nursery areas of good condition need to be guaranteed. This can be achieved by river restoration measures. For instance, addition of stones and gravel can help spawning and nursery habitats to recover, while removal of dams or building fish passages will re-establish the lost but fundamentally important connections between the sea and the riverine spawning sites. When most successful, river restorations do not only improve living conditions of migratory fish but rehabilitate the entire river ecosystem.

As the importance of healthy rivers is starting to be widely acknowledged, there is an increasing interest and societal demand for the recovery and restoration of rivers and migratory fish populations in the Baltic Sea region. River restoration may require considerable investments of private or public resources, implying also high effect expectations. However, resources for restoration ventures are often scarce, which highlights the importance of a well-informed choice of restoration projects and sound practices for carrying out them. Successful river restoration requires extensive and multifaceted knowledge about relevant hydro-morphological, ecological, social/cultural, economic, and legal as well as policy aspects. The EU Interreg project RETROUT, has focused on Baltic Sea sea trout and addressed aspects of river restoration to strengthen migratory fish populations. Through a number of thematic activities, useful experiences have been gained and knowledge gathered on Baltic Sea sea trout rivers and river restoration. As one step towards better river restoration projects RETROUT has compiled this Baltic Sea river restoration best practices guidelines report.

1.1 Status of Baltic Sea rivers and migratory fish species

Numerous streams and rivers (~8500 main rivers in the Baltic Sea drainage area; Vogt et al. 2007) discharge to the Baltic sea. These running waters differ in size from a number of major-sized rivers to countless small streams and ditches. Most of these waters are highly affected by human activities through different water regulation measures, agriculture and forestry, drainage of wetlands, community and industrial wastewaters, and past measures to clean up rapids to function as transport routs. Rivers in the Baltic sea region are managed nationally or internationally (in the case of transboundary rivers) through EU water policy and national water legislation of the Russian Federation. Based on the criteria of EU Water Framework Directive (WFD; Box 1), less than 40% of all the river waters under EU jurisdiction have reached the set target of a ‘good ecological status’ (Grizzetti et al. 2017, EEA 2018). Of the roughly 25000 rivers and streams of the Baltic sea drainage area assessed under the EU WFD only about 30% had good or high ecological status (WISE 2021), with Finland having the highest (62%) and Germany the lowest (3%) proportions of rivers achieving the WFD target (Table 1).

As a consequence, many fish populations migrating between rivers and the sea have been degraded. Salmon and sea trout together with European eel and migratory whitefish (*Coregonus lavaretus/Coregonus maraena*) constitute keystone diadromous species in the Baltic Sea (ICES 2020). Also, many Baltic Sea freshwater coastal species that are non-obligate migratory species often utilise rivers and brooks for spawning (Engstedt et al. 2010, Rohtla et al. 2014). According to the HELCOM Red List for the Baltic Sea, eel is classified as critically endangered, whitefish as endangered, and salmon and sea trout both as vulnerable, with migration barriers listed as a current and future threat alongside fishing for all four species (HELCOM 2013). Additionally, Baltic Sea lamprey species (sea lamprey, *Petromyzon marinus* and river lamprey, *Lampetra fluviatilis*) depend on rivers and are affected by similar problems as migratory fish. Sea lamprey is classified as vulnerable and river lamprey as near threatened (HELCOM 2013). Of these migratory species, sea trout has been a common in most of the rivers and streams flowing to the Baltic Sea.

The latest evaluation of the HELCOM core indicator on sea trout shows that of the 310 evaluated sea trout populations 54% had good status[1], with a status less than good in most of northern Baltic Sea (especially Gulf of Bothnia), but better in parts of the central and southern regions (HELCOM 2018a). Comparably, in the latest ICES WGBAST[2] assessment (ICES 2020) a general slight decline in status was observed in the last years the average recruitment status[3] (RS) of sea trout being highest in the Gulf of Finland (RS~100 %) and poorest in the southern Baltic Sea (RS~30%). Habitat degradation, migration barriers, and fishing are the main pressures on sea trout in the Baltic Sea, with habitat destruction affecting more than 40% of reported populations (ICES 2020). In addition to the negative ecological consequences, the degradation of sea trout populations also reduces the possibility to sustainably use these species as resources by fisheries. Coarsely around 500 tonnes of sea trout are caught yearly of which over 50% by recreational fisheries (ICES 2020).

Table 1. The ecological status of rivers in the Baltic Sea drainage area assessed under the EU WFD (WISE 2021)

Country	**Rivers with 'Good' or 'High' ecological status (2018)**
Denmark*	26.4%
Estonia	60.4%
Finland	61.9%
Germany	3.0%
Latvia	20.7%
Lithuania	48.9%
Poland	30.7%
Sweden	31.7%

*Due to delineations of River Basin Districts some Danish rivers belonging to the Baltic Sea drainage basin might be missing.

[1] Good status is defined as the ratio of observed parr densities in relation to reference potential parr densities yielding 50 or more. Assessment was based on data from 2011–2016 and expert evaluations.
[2] ICES Assessment Working Group on Baltic Salmon and Trout
[3] Recruitment status = (Observed density / Predicted maximal density) * 100 (ICES 2011a, 2021).

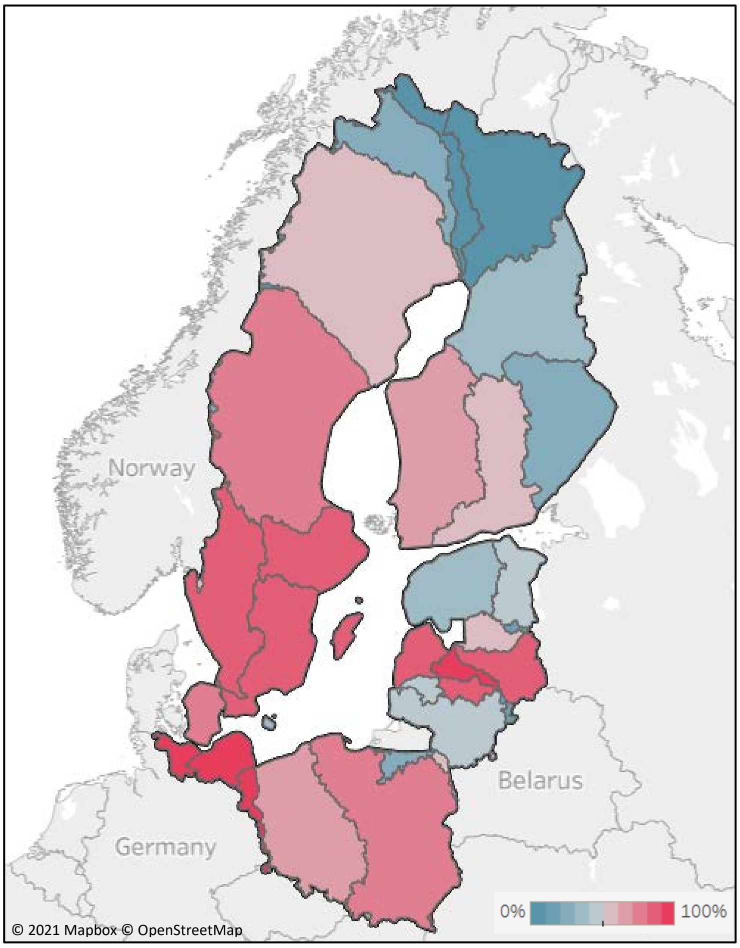

Figure 1. Percent of rivers by River Basin District failing to achieve good environmental status according to EU WFD (WISE 2021). Due to delineations of River Basin Districts some Danish rivers belonging to the Baltic Sea drainage basin might be missing.

1.2 Need for measures to improve the status of rivers and riverine fish

Rivers in good condition can carry out and provide diverse ecosystem functions and services. Ecosystem functions are defined as interactions between biophysical structures, biodiversity and ecosystem processes, and can relate to the production of organic matter, stabilising of natural processes (e.g., floods), water self-purification, landscape structuring and organisation/facilitation of biodiversity (GWP / INBO 2015). These ecosystem functions are important because they provide provisioning, regulatory, cultural and supporting services that are beneficial for us in a general sense but also crucial for sustainable economic activity (GWP / INBO 2015). Rivers in better ecological status can deliver a higher level of ecosystem services (Grizetti et al. 2019). Therefore, good ecological condition securing sustainable ecosystem functioning and the provisioning of ecosystem services should be strived for in water management. This is urgently topical since aquatic ecosystems in general are increasingly degraded by a variety of human pressures, and there is a pressing need to halt the loss of biodiversity change the course by enabling natural recovery or by active restoration (Geist and Hawkins 2016).

Many of the rivers in the Baltic Sea region and the migratory fish population they support are in less than good condition. These rivers are largely affected by habitat degradation and loss of river continuity (EEA 2018). However, the contexts and causes behind poor river condition might be plentiful. On the European scale, degradation of rivers has descended from various human needs and priorities as a result of industrialisation, urbanisation and intensification of agriculture, resulting in direct river engineering activities and more indirect alteration of rivers and their floodplains (Nijland and Cals 2001). These activities are commonly related to flood protection, water supply and hydroelectricity (ECRR 2021). Direct dredging of rapids from stones and boulders or excessive deposition of fine sediments due to forestry and wetland draining are courses for habitat degradation, alongside with pollution and eutrophication of river waters. Dams for hydroelectricity and other barriers (weirs, sluices, culverts, etc.) for water steering and regulation fragment the river continuity. All these degradations from a natural state of a river negatively affect river biota and migratory fish. For instance, in Europe only a limited number of viable migratory fish populations remain in the very few rivers in natural condition unaffected by migration barriers (Garcia de Leaniz et al. 2019, van Puijenbroek et al. 2019).

To address the situation of poor river condition and to take action for improving it, restoration of coastal rivers is one of the few, if not the only sustainable measure to be taken. Restoration measures can include for instance various habitat improvements and securement of up- and down migration to improve river condition and reinstate naturally viable and self-sustaining migratory fish populations. Broadly, river restoration entails a large selection of ecological, physical, spatial and management measures and practices, aimed at re-establishing the natural state and functioning of a river system to improve its resilience and the services it can provide (ECRR 2021).

River restoration is an integral element of sustainable water management, directly supporting the aims of the EU WFD as well as national and regional water management policies (GWP / INBO 2015). The recent EU Biodiversity Strategy for 2030 (BDS 2030) further emphasises the need for greater efforts to restore freshwater ecosystems to achieve the WFD objectives, by, e.g., setting the target of restoring at least 25 000 km of rivers into free-flowing rivers by 2030 (European Commission 2020). The current Baltic Sea Action Plan (BSAP) of the Helsinki Commission (HELCOM) also commits to the development of restoration plans in suitable rivers to reinstate migratory fish species (HELCOM 2007), and the updated HELCOM Baltic Sea Action Plan, which is due to be adopted in October 2021, will also include objectives related to restoration and recovery of river habitats and migratory fish (HELCOM 2020). At global scale, restoration of river ecosystems and preservation of migratory fish species relates the United Nations framework for Sustainable Development Goals (SDGs) that supports protection and restoration of water-related ecosystems (SDG 6 'Clean water and sanitation'), urges restoration of coastal ecosystems and fish stocks to (SDG 14 'Life below water') and aims at restoring inland freshwater ecosystems (SDG 15 'Life on land'). River restoration is also connected to the goals and processes under the UN Biodiversity Convention (CBD), including the Post-2020 Biodiversity Framework, and the targets of the Strategic Plan for Biodiversity 2011–2020 (Aichi Targets).

A wide range of restoration actions has been undertaken in the different EU countries and the Baltic Sea region already before and especially since the operationalisation of programmes of measures under the EU WFD and other international and national policies. However, despite massive efforts for river restoration, widespread underachievement is reported (Palmer et al. 2010, Nilsson et al. 2015). While a special attention to the coastal rivers in Baltic Sea region appears to be missing, in general many restoration projects are contended to have failed to deliver the ecological, hydrological, morphological, and societal benefits envisioned (Haase et al. 2013, Geist and Hawkins 2016). According to recent European Waters Report, good overall ecological status for European rivers have yet not been reached, implying weaknesses in current approaches to planning and implementation of river restoration (EEA 2018). All this clearly demonstrates an imminent need for better river restorations including sound use of measures and improved project practices.

Box 1. The EU Water Framework Directive (WFD).

EU WFD is a European directive and water policy framework (European Commission 2000). The target of the WFD is to achieve good status in all European surface waters by 2015.

The water status is based on the following three groups of parameters:

- Biological parameters: relating to composition and abundance of aquatic flora and fauna;
- Hydromorphological parameters: accounting for the hydrological regime, the ecological continuity and morphological conditions;
- Chemical and physico-chemical parameters: chemical parameters relates i.e. to the content of different polluting substances, and physico-chemical parameters to factors supporting the biology

In are considered as having at least

According to these criteria, good ecological status is considered to compare to undisturbed pristine water cycle and aquatic ecosystems.

More information:

http://ec.europa.eu/environment/water/water-framework/index_en.html

1.3 Rationale for this river restoration best practices report

Much work still needs to be done to achieve overall good environmental status of Baltic Sea migratory fish and their river habitats, and to reach sustainability across all human activities affecting the sea. For the Baltic Sea region, with its shared environment and resources, similar geo-climate, and joint commitments, it is conducive to jointly identify, compile and disseminate practices that lead to successful river restoration projects. These practices broadly cover aspects related to project prerequisites, realisation and feasibility, sustainability, and essentially to impact and effectiveness ultimately for improving migratory fish populations.

This report has been jointly developed within the RETROUT project (Box 2) to support planning and implementing river restoration projects and measures in the region. It is based on reports from dedicated studies (see Chapter 3 for more information) carried out within the project and gathered experiences and expert knowledge existing within the project team. The aim of this report is to list best practices and recommendations for successful river restoration for enhancing the ecological quality of Baltic Sea rivers and to rehabilitate populations of sea trout and other migratory fish. The specific transnational added values are the possibilities for better river restoration projects for and improved ecological status of rivers and sea trout populations in the Baltic Sea region. This in turn can increase the productivity of sea trout and other migratory fish, offering better opportunities to strengthen recreational fishing and fishing tourism industries. The output will support national and EU-level work on developing conservation and management of migratory fish through river restorations and can contribute to regional efforts to consider and further develop HELCOM recommendations for improving the status of sea trout and other migratory fish in the Baltic Sea.

The report focuses on river restorations with primary objectives to improve migratory fish populations, especially sea trout. As a number of river restoration manuals already exist, the purpose of this report lies in its region-specificity and scope. While most existing river restoration manuals give detailed practical advise on how to do the restoration work itself, this report strives to describe the best practises for the whole process of conducting successful restoration projects, from initial identification of the problem and evaluation of the need for a restoration, to planning, practical implementation, and impact and success evaluation. The identified best practices and recommendations of this report are based on input from expert knowledge and other RETROUT work, namely a study on river restoration success factors analysed from past projects, and experiences from actual river restoration demonstration cases carried out within the project. The report has been reviewed by HELCOM Fish-M Task Force and Fish Working Group.

This river restorations best practices report is aimed at practitioners and authorities involved in river restorations. The report gives first a brief background account on the theory of river restorations, continuing with the chapter on purpose, methods and approaches used for the report. Next is following the summary chapters on the main input elements of the best practices. And last, the report ends with chapter 7 synthesising the input materials in river restoration best practices and recommendations.

Box 2

RETROUT – *Development, promotion and sustainable management of the Baltic Sea Region as a coastal fishing tourism destination*

With 14 partners from Estonia, Latvia, Lithuania, Poland and Sweden, and including HELCOM, RETROUT is a 3 ½-year Interreg project running until end-March 2021. RETROUT is a flagship project of the EU Strategy for the Baltic Sea Region Policy Area Bioeconomy. It is co-financed by the Interreg Baltic Sea Region Programme under the Natural resources priority field.

Part of the RETROUT project focuses on assessing sea trout stock and river habitat status, and on evaluating river restoration practices to improve trout populations. By improving the environment in rivers around the Baltic Sea and developing destinations and ethical guidelines for fishing tourism, RETROUT promotes healthy environments and development of sustainable fishing tourism.

More information: RETROUT project homepage https://retrout.org/

Baltic Sea Fishing http://balticseafishing.com/

2 Conceptual background for river restorations

Rivers are running freshwater bodies that serve as important aquatic ecosystems, but are increasingly exposed to anthropogenic pressures, causing their degradation and deterioration. In Europe, the history of altering river courses and other surface water bodies is centuries old (Petts et al. 1989). Common examples include straightening and channelisation, disconnection of flood plains, land reclamation, dams, weirs, and bank reinforcements to facilitate agriculture, produce energy or protect against flooding. Seen as beneficial to mankind, these activities have however caused serious damage to the morphology, hydrology and ecology of water bodies. Changes of a river water course can include a combination of hydro-morphological and physico-chemical quality elements that all are important for a well-functioning river environment (Lin et al. 2018). If river morphology is degraded or the water flow is markedly changed, despite good water quality, a river or any other water body will not reach its full potential as an aquatic ecosystem (EEA 2018).

Hydro-morphological and physico-chemical elements support the biological elements in rivers. Fish are particularly susceptible to hydro-morphological pressures, particularly impacts such as interruptions in longitudinal continuity, riverbank constructions, large flow fluctuations, and water abstraction (e.g., Darwall and Freyhof 2016). Resultant habitat alterations affect fish abundance and diversity. Especially migratory fish species that move between the sea and river headwaters to reproduce are dependent on accessible migration routes. Hence, lost river continuity often leads to changes in fish composition and abundance (EEA 2018, Lin et al. 2018). Physico-chemical quality comprise fundamental aspects for the living condition in the river, such as light and thermal conditions, oxygenation conditions, salinity, nutrient conditions, pollutants, and acidification condition. Fish are very sensitive to changes in these conditions, affecting their survival (EEA 2018).

River restoration is an important means for reversing occurred changes in the hydro-morphological and physico-chemical quality elements and for improving the environmental conditions in river courses. Restoration is conceptualised as the process of “reestablishment of the structure, functions, and natural diversity of an area that has been altered from its natural state” (Pess et al. 2003). It denotes an “intentional activity that initiates or accelerates the recovery of an ecosystem with respect to its health, integrity and sustainability” (SER 2004). A primary goal of restoration is thus said to be re-establishment of interactions among ecosystem components and environmental disturbances (SER 2004). Consequently, river restoration should encompass measures for restoring the hydro-morphological and physico-chemical parameters that, in turn, have great potential to enhance the biological component in these aquatic ecosystems. River restorations include a variety of measures, e.g., removing obstacles and installing fish passes to ensure river continuity, improving physical habitats, restoring the natural water flow regime through setting of minimum flow and ecological flow requirements, and developing master or conservation plans for restoring the population of threatened fish species (EEA 2018).

2.1 River restoration theory and concepts

River restoration is a process guided by a theoretical body of knowledge rooted in the notion of ecological restoration. As a sub-type within this wider concept, it can be seen as representing “a solutions-based approach that engages communities, scientists, policymakers, and land managers to repair ecological damage and rebuild a healthier relationship between people and the rest of nature” (Gann et al. 2019).

According to the “International Principles and Standards for the Practice of Ecological Restoration” (the Standards) developed by the Society for Ecological Restoration (SER), eight principles essentially underpin ecological restoration (Gann et al. 2019). Principles 1 and 2 articulate important foundations that guide ecological restoration: effectively engaging a wide range of stakeholders, and fully utilising available scientific, traditional, and local knowledge, respectively. Principles 3 and 4 summarize the central approach to ecological restoration, by highlighting ecologically appropriate reference ecosystems as the target of restoration and clarifying the imperative for restoration activities to support ecosystem recovery processes. Principle 5 underscores the use of measurable indicators to assess progress toward restoration objectives. Principle 6 lays out the mandate for ecological restoration to seek the highest attainable recovery. Tools are provided to identify the levels of recovery aspired to and to track progress. Principle 7 highlights the importance of restoration at large spatial scales for cumulative gains. Finally, since ecological restoration is one of several approaches that address damage to ecosystems, Principle 8 clarifies its relationships to allied approaches on a “Restorative Continuum”.

The principles for ecological restorations are holistic, and their adoption can go a long way in supporting river restoration efforts. However, certain dimensions are additionally considered in relation to restoration of aquatic ecosystems in general and rivers in particular. For instance, aquatic restoration can be considered as a process comprising ecological aspects, technical feasibility and socioeconomic context (Pander and Geist 2013). The ecological dimension can include the rehabilitation of the physical-structural properties (e.g., restoring connectivity), chemical properties (e.g., reduction of excessive amounts of contaminants), or focus directly on biodiversity itself (e.g., reintroduction of fish populations; Geist and Hawkins 2016). Technical factors include required skills, availability of standards guiding restoration, choice of materials and methods, physical/hydro-morphological realities setting limits to what is possible to construct or modify, accessibility to the restorable area/site by workers and machinery, as well as the time needed for implementation. Socio-economic factors include the cost and acceptance by stakeholder groups, feasibility, desired target states and chances of success (Geist and Hawkins 2016).

More specifically, eight ‘golden rules’ of strategic river restoration have been defined (Speed et al. 2016). The first rule is to identify, understand and work with the catchment and riverine processes, understanding the physical, chemical and biological processes that drive river health. Second is to establish linkage to socio-economic values and integrate restoration with broader planning and development activities. Third is to restore ecosystem structure and function by working at the appropriate scale to address limiting factors to river health. Fourth is to set clear, achievable and measurable goals. Fifth is to build resilience to future change by considering likely changes in the landscape over time, including to the climate, land use, hydrology, pollutant loads and the river corridor. Sixth is to ensure the sustainability of restoration outcomes over the long term. Seventh is to involve all relevant stakeholders, involving interagency and community collaboration. Finally, the eight rule is to monitor, evaluate, adapt and provide evidence of restoration outcomes, with the purpose of guiding adaptive management.

The theory, principles and rules of ecological restoration and river restoration represent an integrated conceptual framework against which effective river restoration practices can be designed and implemented. These are further reinforced through practical guidelines to support implementation of effective and efficient restoration. For example, according to one set of guidelines, a restoration action should start with a good restoration planning process. This, in turn, should have four distinct steps: (1) identifying the restoration goal, (2) selecting a project prioritization approach that is consistent with the goal, (3) using watershed assessments to identify restoration actions, and (4) prioritizing the list of actions (Beechie et al. 2008). A well-crafted restoration goal should identify the biological objective of restoration, address underlying causes of habitat change, and recognize that social, economic, and land use objectives may constrain restoration options (Beechie et al. 2008). Overall, restoration and rehabilitation projects benefit from clear structure of project processes. The ideal procedure of rehabilitation projects involves consecutive project phases (Holl and Cairns 1996, Woolsey et al. 2007). In practice the set-up might vary between projects due to context-specific aspects, but a generic restoration project process should include the following phases: 1) strategic planning, 2) preliminary survey, 3) projection, 4) implementation, and 5) use (Woolsey et al. 2005). Phase 1 involves the initiation of the project including identification of the current condition in the river and the pressing problem, as well as the definition of a guiding image or reference state to aim for. In phase 2 objectives are established and alternative solutions identified, assessed and finally chosen, based on the understanding of the needs and limitations in hand. Phase 3 comprises the detailed planning and design of the chosen solution and of project evaluation, as well as the practical preparations for implementation. Phase 4 is the concrete implementation phase where the planned measure is executed. And finally phase 5 is the post-implementation phase, often overlooked but nevertheless important, including monitoring and project effect and success evaluation, communication and dissemination of project results, as well as adaptive management of the restoration site and measure.

2.2 Restoration project management and sustainability perspectives

Despite the conceptual framework, practical guidelines, and massive capital investments, river restoration is claimed to have underachieved, with many restoration projects failing to deliver the anticipated hydrological, morphological, ecological, and societal benefits (Geist and Hawkins 2016; Haase et al. 2013; Johnson et al. 2020). This may be a result of inadequate or faulty translation of the theory into practice or lack of integrated approaches. As river restoration is almost always organised in the 'project' mode[4], the success of a restoration project ultimately is the concern of project management. In this context a 'project management approach' connecting project management with sustainability is relevant in the planning and implementation of the restoration efforts. Sustainability refers to the different approaches and connections that project management can have with environmental, social, and economic dimensions and problems (Whiteman et al. 2012, Sabini et al. 2019). The sustainability perspective is relevant because although river restoration projects by their basic nature are temporary interventions, the objectives of restoring hydro-morphological, physico-chemical quality and biological elements focus on long-term horizon. Further, being temporary projects, they need to be capable of planning, designing, and organising the activities most efficiently and effectively in terms of resources, manpower, skills, techniques and other necessary inputs.

Delivering 'success' in river restorations in a long-term perspective thus relates to two significant inter-connected dimensions, namely, 'sustainability *by* the project' and 'sustainability *of* the project'. The former implies that the project delivers a sustainable good or service while the latter implies that the project is delivered following sustainable processes (Huemann and Silvius 2017). The intersection between project management and sustainability is conceptualised as 'sustainable project management', further defined as "the planning, monitoring and controlling of project

[4] A project can be conceptualised as 'a series of actions aligned according to a specific goal' or as 'a concrete and organised effort that leads to the realisation of a deliverable'. Projects have an intrinsic time element, with a beginning and an end (Mesly 2016).

delivery and support processes, with consideration of the environmental, economic and social aspects of the life-cycle of the project's resources, processes, deliverables and effects, aimed at realising benefits for stakeholders, and performed in a transparent, fair and ethical way that includes proactive stakeholder participation" (Silvius and Schipper 2014, p. 79).

For river restoration projects the following sustainability dimensions of project management processes and practices could be considered as important: context of the project that integrates ecological, economic and social aspects, identification of stakeholders, project specifications and quality criteria, costs and benefits, criteria for measuring project success, selection and organisation of the project team, project activities and schedule, availability of financial and other resources, risk identification and management, stakeholder involvement, and project communication (Silvius and Schipper 2014, Sabini et al. 2019).

In practice sustainability dimensions are not widely followed in river restorations. Often restoration measures can be a means to 'do something' and are based on limited finances and insufficient judgement on the most cost-effective solution. Simple measures leading to quick improvements are favoured to demonstrate progress, but more complex situations where multiple stressors act on a larger scale, and where multiple stakeholders need to be involved, are avoided (Kuijper et al. 2017).

2.3 Stakeholder participation

At the core of the concept of sustainable project management, integrating the perspectives of a broad group of stakeholders, in turn leading to co-creation of project benefits with them, is repeatedly highlighted (Sabini et al. 2019). A stakeholder is defined as an actor who under certain circumstances has interest for the matter, has influence on a problem, and has positive or negative impact by policy decision and its enforcement (Varvasovszky and Brugha 2000, Tanaka 2006). The role of stakeholders is considered important at various stages, including planning, implementation and post-project maintenance (Carr 2015, Druschke and Hychka 2015, Reilly and Adamowski 2016). Consequently, stakeholder analysis can be helpful for understanding differences and commonalities of interests between stakeholders, and for proposing practical mediation for more effective outcomes (Tanaka 2006).

Stakeholder participation helps enhance river restoration projects through the following mechanisms: (1) providing space for deliberation and consensus building for better quality decisions, (2) mobilising and developing human and social capital for better quality decisions and their implementation, and (3) raising the legitimacy of decisions to facilitate their implementation (Carr 2015). It is also contended that appreciation and integration of local communities and their local ecological knowledge can greatly enhance progress in addressing challenges to river restoration (Szałkiewicz et al. 2020). In relation to ecological restoration, one study advises managers to consider their desired social-ecological outcomes and work from the outset to deliberately design mechanisms for communication and public engagement that weave community stakeholders into all phases of restoration projects in sustained and consequential ways (Druschke and Hychka 2015).

Further, river restoration projects can be essentially seen as causing change in the appearance as well as the social, ecological and economic function of a public environment. Since the river can represent a 'physical place', a 'social and cultural locus', and a 'symbol for the total environment', this can lead to conflicts related to values, stakeholder relations and coordination, and opposing interests regarding e.g., flood protection, leisure usage, policy and economy. Thus, the planning and implementation of river restoration projects must live up to expectations of multiple stakeholders, and hence an inclusive approach involving different interest groups and individuals is important (Heldt et al. 2016).

2.4 Evaluation of river restoration projects

In light of the theory and practice that can guide efficient, effective and sustainable river restoration projects, it is important to evaluate their status, processes, outcomes and impacts. Setting restoration targets a priori and evaluating how they have been met, is fundamental for sensible analysis of project success, further facilitating learning for improved future projects (Woolsey et al. 2007). In this context, it is important to acknowledge and separate evaluation of whether the restoration measure brought about the desired ecological impact (effect evaluation), and a more holistic evaluation of the project success which can include both a process evaluation (how was the whole project process carried out) and the effect evaluation. An evaluation can help in detecting flaws such as in project design or implementation, and enable additional actions required if the objectives are not achieved (Bash and Ryan 2002, Woolsey et al. 2007). Lessons learnt from both restoration failures and successes are valuable in order to identify any barriers that may require corrective action or positive actions that may be replicated in future projects. Project evaluation can prepare future projects in the same or different rivers. This is desirable for sustainable water management, and for assessing the progress towards reaching the specific policy goals, such as that of the EU WFD or the HELCOM BSAP.

The criteria for evaluation of a river restoration project as success or failure should be closely connected to the ecological, social and economic sustainability elements. Key questions for judging a restoration project could be: Did the restoration effort help in reaching the ecological goal(s)? Were the stakeholders involved in the process of designing and implementing the project and are they satisfied with the outcome? Was the project accomplished cost-effectively? How were the project's secondary objectives, such as preservation and development of existing cultural, historical, recreational, and infrastructure values, fulfilled? (Palmer et al. 2005, Morandi et al. 2014). While some of these questions relate to the overall project goal – essentially ecological – others like those connected to stakeholders' interest and their participation are more connected to the project processes.

Despite the importance, evaluation and feedback on outcomes of river restoration projects are seldom performed (Morandi et al. 2014). This can be due to insufficient funding, time constraints or shortage of workforce (Bash and Ryan 2002, Woolsey et al. 2007). Lack of evaluation guidelines and failure to set clearly defined project objectives at the outset are additional reasons (Woolsey et al. 2007). Also, the quality of an evaluation strategy often remains too poor to understand well the link between a restoration project and ecological changes, and in many cases the conclusions drawn are contradictory, making it difficult to determine the project's success or failure (Morandi et al. 2014). Therefore, there is need to develop more comprehensive evaluation frameworks that can holistically assess the success or failure of river restoration projects by linking them with the notion of sustainability and considering criteria along all the three axes of sustainability.

2.5 Brief view on existing literature and sources of information on river restorations

River restorations have been practised for years, and theories, concepts, advice and instructions have been developed accordingly to support restoration activities. This knowledge and information have been disseminated through various technical reports, manuals, handbooks, guidelines and scientific papers. These publications can provide e.g., useful theory frameworks, comprehensive handbooks for carrying out restoration projects, technical manuals on different restoration measures and methods, as well as material to support and inform on restoration effect and success evaluation. Additionally, a number of useful online resources and services are available as information and aid for restoration practitioners and new ventures.

Few examples of comprehensive handbooks relevant for river restoration are '*The handbook for management and restoration of aquatic ecosystems in river and lake basins*' (GWP / INBO 2015), '*River Restoration: A Strategic Approach to Planning and Management*' (Speed et al. 2016), '*Rivers by Design: Rethinking Development and River Restoration*' (RESTORE 2013). GWP / INBO 2015 provides practical information for assisting management and restoration of freshwater ecosystems. RESTORE 2013 provides practical advice and information on for planners, designers and developers on river restoration and protection with best practice case study examples of successful past projects. Speed et al. 2016 is a very comprehensive handbook on principles and practices for planning, implementation and management of river restorations. Additionally, in the scientific literature there are overviews and reviews on contemporary understanding and practices in the field of river restorations. These, for instance, examine challenges in the scientific comprehension of river restoration processes as well as how practitioners approach divers aspects of river restorations, including restoration objectives, holistic ecosystem understanding, and social process in relation to restoration (Wohl et al. 2015), or assess the changes in the effect of different drivers of river restoration (Smith et al. 2016), or propose new research themes to advance the scientific basis for river restoration (Wohl et al. 2005).

Many practical and technical national and general manuals exist concretely guiding the choice and implementation of restoration measures (e.g., RRC 2020, Urtāns 2017). Also, for example, an inventory of practical river restoration measures has been produced under an EU-funded project REFORM (Ayres et al. 2014) where these are assessed from cost and benefit perspectives. There are also reports available with concrete case study examples for demonstration various restoration needs, solutions and measures and their practical implementation (e.g., Golfieri et al. 2017).

For evaluating the river restoration projects, several different kinds of frameworks, guidelines and standards are available (e.g., Palmer et al. 2005). Among the detailed guidelines is the one developed by Woolsey et al. (2005, 2007), which is based on a total of 49 indicators and 13 specific objectives relating mostly to ecological goals but also to socio-economic aspects. Examples of surveys of river restoration projects aiming at sharing experience about evaluation of restoration are few, with examples including those from the European Centre for River Restoration (http://www.ecrr.org/); the National River Restoration Science Synthesis in the USA (Bernhardt et al. 2007), and the Asian River Restoration Network (http://www.a-rr.net/). In France, Onema, the French National Agency for Water and Aquatic Environments has developed a database documenting the realisation of actions for river restoration and published a number of documents, including guidebooks on the subject, including one on assessing the passage of obstacles by fish (Baudoin et al. 2014). Several comprehensive studies have been carried out to understand and analyse the success and failures of river restoration projects within EU and other regional contexts (Jähnig et al. 2011, Muhar et al. 2016). One such study was based on evaluation of success in 44 French pilot projects. The study emphasized the importance of a good evaluation strategy based on clearly defined objectives so as to effectively assess the success or failure of a restoration project (Morandi et al. 2014).

Finally, some relevant and useful internet resources regarding river restoration are: European Centre for River Restoration (http://www.ecrr.org); World Fish Migration Foundation (https://worldfishmigrationfoundation.com); Dam Removal Europe (www.damremoval.eu); RiverWiki RESTORE (https://restorerivers.eu); the AMBER project (https://amber.international).

3 Purpose, methods and approaches of the report

The purpose of this report is to provide best practices and recommendations for river restoration projects in the Baltic sea region with the focus on improving migratory fish populations and especially sea trout. The report summarise all the lessons learned within the RETROUT project concerning the work done on river restorations. The best practices are to be used by local, regional, and national public authorities and river restoration practitioners or other. This report aligns well with the current and updated HELCOM BSAP interests and priorities related to migratory fish and restoration of essential habitats, and further relates closely to the HELCOM Recommendation 32-33/1 ('*Conservation of Baltic salmon (Salmo salar) and sea trout (Salmo trutta) populations by the restoration of their river habitats and management of river fisheries*').

This report and the river restoration best practices are built upon on the outcomes from two main activities in the RETROUT project, namely 1) a study evaluating factors of success and failure from past restoration projects (Chapter 5, Singh et al. 2021), and 2) a number of concrete river restoration projects conducted in course of the RETROUT project (Chapter 6, Supplementary report[5]). Largely based on the key take-home messages and lessons learned from this material, the best practices for river restoration projects in the Baltic Sea region have been synthesised (Chapter 7). Both first-hand information of experiences from different types of restoration projects and analytical results from a considerable number of various past restoration cases have been gained and used for developing the best practices. Additionally, as the important prerequisite for planning and evaluating river restoration measures, a summary on a selection of relevant river and sea trout monitoring methods are provided (Chapter 4).

3.1 Rationale and methods of RETROUT study on river restoration success factors

The overall aim of RETROUT study on river restoration success factors was to reveal factors of success and failure in river restoration projects in the Baltic Sea region. The task was to undertake an evaluation of past river restoration projects, mainly regarding measures of habitat restoration and solutions for migration barriers.

The study was based on a qualitative analysis of data collected from river restoration projects planned and/or implemented in the Baltic Sea region. Considering that the evaluation involves a comparison of the different restoration projects, the 'comparative case study approach' was adopted as the basic methodology. A detailed account on the methodological framework of the 'Comparative case study approach' is given in the original study report (Singh et al. 2021).

3.1.1 Data collection and analyses

For this study data on past river restoration projects was used. The data explicitly concerned potential sea trout rivers flowing to the Baltic Sea. Data collection was organised in two successive rounds. First, through wide data request to RETROUT project partners and HELCOM Contracting parties on past river restoration cases in the sea trout rivers in the Baltic Sea region. And then, through in-depth interviews on a sub-sample of the received restoration cases. Data was procured from five RETROUT partner countries, namely, Estonia, Latvia, Lithuania, Poland and Sweden in both

[5] The Supplementary report is a compilation of the RETROUT river restoration case reports. The report is accessible via [HELCOM publications page](). The direct link to the report is: https://helcom.fi/wp-content/uploads/2021/03/RETROUT-River-Restoration-Demonstration-Case-Reports_v.4.pdf

the rounds. Additional data were requested from the other Denmark, Finland, Germany and Russia. Of these, input was received from Denmark and Russia in round 1. Russia further participated in round 2, while data from Finland was procured in round 2.

In round 1, data sets of cases were received on two kinds of river restoration projects, namely 'completed' projects that were planned and implemented in the past, and 'non-realised' projects that were planned but failed to be executed or completed. The completed projects were classified as 'success', 'partial success' or 'failure' basis on fulfilment of the restoration goals. Restoration project evaluation was done by the data provider, based aspects of restoration objectives and success indicators detailed in a provided survey template (modified based on Woolsey et al. 2005, 2007). The received data was compiled for each country and were used for drawing an overview of the situation across the Baltic Sea region.

In round 2, from the round 1 data sets, a stratified purposeful sampling of 2–3 restoration projects per country was made to capture the diversity across river restoration projects, to be used for the in-depth comparative case study analyses. For further data collection of the sub-sampled cases, an interview guide was prepared, containing questions addressed to three kinds of stakeholders, namely the implementing agency, a supporting stakeholder, and an opposing stakeholder. The three stakeholder interviews per each selected project provided in-depth information on the important factors for success and failure from the respective perspectives. A total of 38 interviews were conducted in the different countries. The data procured was subject to qualitative analysis for drawing results related primarily to the following dimensions:

a. Background /context of the restoration project
b. Overall aim, and temporal and spatial scale of the project
c. Evaluation of the project as a success or failure
d. Role of stakeholders external to the implementing agency
e. Problems encountered in implementing the restoration project/activities
f. Lessons learned
g. Factors behind success or failure of the project

Emerging repeated elements from the above dimensions were separated and grouped under relevant data categories. A comparative case study analysis was carried out for finding generalities and drawing conclusions.

The study was carried out jointly by the RETROUT project team from the different partner countries. The lead in designing and executing the study was taken by UCV-CR, Sweden, supported closely by the Work package 4 leader HELCOM. Data collection was coordinated by specific partners in each participating country, namely, the University of Tartu in Estonia, HELCOM in Finland, BIOR in Latvia, Klaipeda University in Lithuania, Gdynia Maritime University in Gdansk, Poland, and County Administrative Board of Stockholm and UCV-CR in Sweden. Data from other HELCOM countries was contributed by the Ministry of Environment and Food, Government of Denmark and Baltic Nature Fund in Russia.

3.2 Rationale and methods of RETROUT river restoration demonstration projects

Within the RETROUT project, efficient river restoration measures and implementation methods were demonstrated as real restoration projects (whole or parts) based on national and transnational knowledge from research and dialogue. The purpose of the restoration projects was to demonstrate river restoration solutions for improving quality of river habitats for sea trout and other migratory species, with the aim to increase and secure sustainable populations. The demonstration projects drew on international peer learning and basin-wide research and may serve as examples that can be replicated in other countries. The specific value at impact level was improved conditions and increased fish production of the project rivers. An important addition was, however, the shared experiences and lessons learned from the restoration cases.

The RETROUT river restorations included 15 restoration cases in 11 coastal rivers from Estonia, Latvia, Lithuania, Poland, and Sweden. The restoration cases cover fish ways, biotope restorations, water quality improvement, and dam removal plans. Careful project documentation was carried out and case reports were produced. Complete restoration case reports with more specific detailed information on each project are available in the compiled joint case report publication (Supplementary report[6]).

3.2.1 Process documentation and report compilation

During all stages of the restoration projects, relevant activities are documented carefully, including monitoring, causal analysis, administration, judicial circumstances, court proceedings, discussion with stakeholders, design and implementation. The process documentations of the restoration projects have generally followed and included, to the applicable parts, the below sequence of events:

1. First, a causal analysis is undertaken. Reasons for weak trout stocks or less than good ecological status are analysed. Then restoration measures are suggested based on the identified causes of environmental issues and current conditions. This results in a checklist of necessary components for a restoration knowledgebase (e.g., GIS analyses, monitoring of migration obstacles, hydro-morphological changes).
2. Cultural heritage, energy production, recreational value and other stakeholder interests are described, and possible conflicting interests are identified.
3. Compromise solutions are developed together with stakeholders that improve all relevant biological parameters, prerequisites for fishing and recreation [if applicable] as well as protect and highlight cultural heritage. Stakeholders are identified, sampled and consulted using different methods, e.g., individual discussions, focus groups, negotiations, public meetings, and opinion surveys, if needed.
4. Planning and design of chosen solutions and restoration measures.
5. Environmental impact assessment if necessary
6. Application to the competent authority. Court proceedings if necessary.
7. Implementation phase. Execution of the plans according to the design.
8. Post-implementation monitoring of restoration target indicators (e.g., sea trout parr density) for evaluation of success.

For increasing success and to gather useful experiences and lessons learned, the restoration projects were provided guidance for organising their stakeholder communication (Supplementary report[6] Appendix 1), as the matter have been commonly considered important.

After completion, each project was evaluated, and the experiences and documented process stages were compiled in the case study reports guided by general reporting instructions (Supplementary

[6] The Supplementary report is a compilation of the RETROUT river restoration case reports. The report is accessible via HELCOM publications page. The direct link to the report is: https://helcom.fi/wp-content/uploads/2021/03/RETROUT-River-Restoration-Demonstration-Case-Reports_v.4.pdf

report[6] Appendix 2). The restoration project reports addressed and included to applicable parts following aspects: basic project information, background account, project initialisation, planning phase, preparations and implementation, and evaluation of the project process and success.

3.3 Rationale and approaches for RETROUT monitoring and assessment methods overview

There are transnational interests in developing common standards for classifying and assessing sea trout river and stock status. In the RETROUT project three methods for monitoring and assessing sea trout river condition and stock status were considered. More specifically, these concerned methods for monitoring and assessing sea trout river habitat quality elements and parr production. The methods were the River Habitat Survey (RHS), the Trout Habitat Score (THS), and electrofishing & parr density estimation (EF&PDE). These methods are central for providing necessary background information for river restoration projects and centrally needed for monitoring and evaluation of the ecological restoration success.

Within the RETROUT project the concerned monitoring and assessment methods have been addressed through reviewing of the method features and through practical testing of the methods in the project countries. This work has been compiled in a summary report, containing a common description for habitat survey methods and river status assessments as well as for trout monitoring and electrofishing, and additionally summaries of the experiences of the testing exercise in selected rivers of the project countries.

The testing of the chosen monitoring and assessment methods were carried out in a selection of rivers in each project country. The responsible national RETROUT project partners (EMI in EE, BIOR in LV, Klaipeda University in LT, and GMU in PL will undertook the national testing. Each country-wise testing was to produce a summary describing the testing scheme done and the experiences gained. The summaries presented information about the test sites, provided a description on how the testing was carried out, including any deviations from regular protocols, and reported results and experiences together with recommendations and improvement suggestions. These nation-specific methods testing summaries then fed into a combined report about sea trout habitat and stock monitoring/assessment methods.

4 Monitoring and assessment methods for planning and evaluation of restoration measures

Insufficient knowledge about the hydro-morphological and ecological background of the environmental condition of a river can hamper successful planning of restoration ventures. These challenges might relate to data quality and methods for monitoring and assessing river condition and sea trout status. Well-functioning monitoring and assessment methods are also centrally needed for the evaluation of both primary and secondary objectives of a restoration as conducted before and after the restoration intervention.

4.1 Summary description of methods

In the scope of the RETROUT project three sea trout river and stock status monitoring and assessment methods were chosen for examination. These were the River Habitat Survey (RHS), the Trout Habitat Score (THS), and electrofishing and parr density estimation (EF&PDE).

The River Habitat Survey comprises a thorough analysis of the hydromorphological conditions of a watercourse. After a completed study, it is possible to draw conclusions about the processes that have shaped the watercourse and created the structures that presently are visible. It is also possible to predict the future development of the watercourse to some extent and to draw conclusions about what measures would improve the conditions. Electrofishing is the standard monitoring method to estimate trout parr density and evaluate the state of the local trout stock. With time series of quantitative electrofishing population trends can be followed and warning signs of deteriorating environment can be detected. The Trout Habitat Score is a relatively newly developed tool to evaluate the suitability of a stream for young trout. The THS can be used as input into a regression model to predict the maximum parr density in a stream. Output of the model can be compared with electrofishing data. Much lower observed parr densities compared to the potential could indicate unknown environmental problems and merits further investigation.

The three methods were tested in the RETROUT partner countries. The full reports of the tests are available at the RETROUT webpage www.retrout.org. In this chapter, a summary of the reports is presented.

4.1.1 River Habitat Survey (RHS)

A stream harbours many different types of structures; everything from sand dunes and block accumulations to erosion pools, that in combination make every stream unique. The structures have been created over a long time when the water has sculpted and rearranged the landscape under its course from source to sea. All these structures are creating different biotopes and are vital for the streams' biological diversity. Despite the uniqueness of the streams, there are also common features recurring across all stream waters. Streams with the same basic prerequisites (e.g., slope, geology, and discharge), show that there are many similarities between them, and the different habitats are not emerging randomly. If a single structure is observed, for example a pool, there is always a physical reason, a hydro-morphological process, for it. The occurrence of these similarities and the common physical causes behind for them, make inventories of streams valuable and useable for instance in the planning of restoration activities, despite their multiple formats.

Through a systematic analysis of structures in and properties of streams it can be understood how the stream functions as a system, and in what ways humans have affected the stream. There are many methods for analysing streams, and the method described in this report is River Habitat Survey

(RHS). River Habitat Survey is a method for describing the physical conditions within and in connection to streams. This RHS method has been developed in Sweden to incorporate hydrological and morphological status with habitat suitability for stream-living fish and other relevant information relating to ecological status of rivers.

In the RHS, the streams are divided into different reaches. For each reach, the habitats, the degree of impact, and the reach's properties are described in a protocol. In addition, there are several optional protocols to be used for inventory of barriers, or for in-depth inventory. After a conducted RHS, the results can be evaluated in different ways. This can concern, for instance, the interaction between different reaches, e.g., how a reach with a lot of erosion affects a reach downstream. The evaluation can also concern the commonness of different natural habitats, as well as the degree of impact and the hydromorphological status of the stream. The results may be used in many ways and can be important for e.g., restoration planning or environmental considerations.

The RHS described in this report has been developed in Sweden. A comprehensive manual for the use of the RHS is published on the RETROUT project website www.retrout.org. The manual includes templates for protocols in paper format. On the website, electronic forms to be used with a phone or tablet (Android or IOS) can be downloaded including a guide on how to use them. One of the main objectives with the RHS is to determine the hydro-morphological type of each stretch – the present type and the original type.

The RHS was tested in a selection of rivers in RETROUT project countries. Experiences from the tests and evaluations of the method in different countries are described in section 4.2.1

Hydromorphological types

Streams can be divided into different categories, called hydromorphological types, based on different characteristics. There are many different systems with different levels of detail for characterisation. One of the division methods entails that the stream is classified after its capacity to transport sediment in relation to how much available sediment there is to transport. The division after transport capacity classify streams as either supply limited ('SL', limited sediment availability) or transport limited ('TL', limited capacity to transport material). In the river habitat survey, these two conditions are treated as two separate groups of hydromorphological types, and in addition, an extra group, peat streams, has been added. This classification does not relate to distinctively separate types of streams but should instead be regarded as a gradient from supply limited to transport limited. At the supply limited end of the gradient the streams are steep with high transport capacity and low sediment availability (e.g., steep bedrock streams with unmovable sediments such as flat rocks and boulders), and at the transport limited end there are fine-grained low-slope streams with lower transport capacity and higher sediment availability (e.g., meandering alluvial streams with movable sediments such as sand, gravel, or finer materials). Between these types of streams there are various stream types with intermediate features. In the River Habitat Survey both the present and the original (before human intervention) hydro-morphological type is determined.

4.1.2 Trout Habitat Score (THS)

The Trout Habitat Score (THS) is an easy-to-use method to estimate parr density in Baltic sea rivers. It is based upon the basic requirements of young sea trout in rivers, and further developed into a model for predicting the potential maximum parr density for a river site. The core of the method is a standardised way to describe the river habitat in relation to the environmental variables that is important for the survival of young trout, parr.

The THS method was applied and tested together with electrofishing in selected sea trout rivers in the RETROUT countries. The results from these tests are presented in section 4.2.2.

Development and use of THS

The THS has been developed within the ICES Study Group on data requirements and assessment needs for Baltic Sea trout – ICES SGBALANST (ICES 2011). Based on a large literature study, the variables found to be most important for the recruitment of parr was the wetted width of stream, slope, water velocity, depth, dominating substratum and shade of the water surface. The variation span of these variables was divided into three classes and given scores from 0 to 2 where 2 is the most favourable for recruitment (Table 2). These variables are measured on a river stretch and summed to get the THS. The maximum value is 12 if all variables are used. However, slope is often not available for a particular stretch and can be omitted. The maximum value is then 10. One advantage of these simple measurements is that they are often available in existing electrofishing datasets of the Baltic sea countries, which is one reason for selecting them.

The THS was then used to develop a model for predicting the potential maximum parr density at a river stretch. The THS values are grouped according to Table 3 to make the variable more robust and less sensitive to variation in parameter estimation. Parr densities is known to vary with climate and river size (ICES 2009). To compensate for this variation, width, annual temperature, latitude, and longitude was included in the model (Function 1) (ICES 2015, Pedersen et al. 2017). The predicted parr density can then be compared to observed values from electrofishing data. The recruitment status is then the percentage of the observed parr density from the maximum parr density (Function 2, Pedersen et al. 2017). Differences between maximum and observed values of parr density can be due to several causes. The THS can thus be used to identify streams with environmental issues that needs to be further investigated.

Function 1. $Log10(0 + optimal\ density) = 0.963 - (0.906 * log(width) + (0.045 * airtemp) - (0.037 * longitude) + (0.027 * latitude) + (THS * 0.033)$

Function 2. $Recruitment\ status = \frac{observed\ Log10\ (0{+}\ density\ {+}1)}{maximum\ Log10\ (0{+}\ density\ +\ 1)} \times 100\%$

Table 2. Trout habitat scoring table (ICES 2011b)

Trout habitat score	**0**	**1**	**2**
Wetted width of stream (m)	>10	6-10	<6
Slope (%) of section	<0.2 & >8	0.2-0.5 & 3-8	>0.5-<3
Water velocity class	Slow/still	Fast	Moderate
Average/dominating depth (m)	>0.5	0.3-0.5	<0.3
Dominating substratum	Fine	Large stones, boulders or sand	Gravel-Stone
Shade (%)	<10%	10-20	>20

Table 3. Grouping of Trout Habitat Score (THS) values into THS classes (Pedersen et al. 2017)

THS Class	**Maximum THS**	
	10	**12**
0	THS < 5	THS < 6
1	THS = 5 – 6	THS = 6 – 8
2	THS = 7 – 8	THS = 9 –10
3	THS = 9 –10	THS = 11 – 12

4.1.3 Electrofishing and parr density estimation (EF&PDE)

Electrofishing is a common scientific survey method used to sample fish populations to determine abundance, density, and species composition. When performed correctly, electrofishing results in no permanent harm to fish, which return to their natural state after being caught. Used incorrectly, the fish can be severely injured by the electricity causing muscle spasms that damage the vertebrae.

Electrofishing relies on two electrodes which deliver direct current at high voltage from the anode to the cathode through the water. The anode is located at the end of a long, two-meter pole and is usually in the form of a ring. The cathode is a long, three-meter braided steel cable that trails behind the operator. When a fish encounters a large enough potential gradient on this path, it becomes affected by the electricity. The current causes uncontrolled muscular convulsion that results in the fish swimming towards the anode, a condition called galvanotaxis. At least two people are required for an effective electrofishing crew: one to operate the anode, and the other to catch the stunned fish with a dip net.

The effectiveness of electrofishing is influenced by a variety of biological, technical, logistical, and environmental factors. The catch is often selectively biased as to fish size and species composition. The pulse rate and the intensity of the electric field strongly influence the size and nature of the catch. The conductivity of the water influences the shape and extent of the electric field and thus affects the field's ability to induce capture-prone behaviour in the fish.

The electrofishing catch is converted to parr density estimates either directly or through the calculations of some removal sampling method (Zippin 1956). More information the method used, and statistical considerations can be found in Bohlin et al. (1989).

Electrofishing is used in all partner countries. In a RETROUT-HELCOM workshop[7] on sea trout population status and habitat assessment methods in Klaipeda, Lithuania, 2018, based on a questionary a comparison of the electrofishing protocols and routines was conducted between the RETROUT countries. In Latvia, a study on the effect of different number of sweeps were done.

4.2 Experiences from test application of sea trout river monitoring and assessment methods

The three monitoring methods considered were tested in some of the RETROUT countries. The RHS was developed in Sweden and is new to all countries except Sweden. The method was tested to identify possible shortcomings in relation to national conditions and possible improvements. Electrofishing has been used before in all partner countries. The effect of different number of sweeps was tested in Latvia, and a comparison with the potential parr density calculated from the THS data was done in Poland and Latvia. For Trout Habitat Score, different modifications were tested and analysed.

4.2.1 Synthesis from RHS testing experiences

The River Habitat Survey was tested in Latvia, Poland, and Sweden. The method involves a thorough analysis of the hydromorphological conditions of a watercourse. After a completed study, it is possible to draw conclusions about the processes that have shaped the watercourse and created the

[7] HELCOM workshop on sea trout population status and habitat assessment methods (HELCOM FISH-M 6-2018). Outcome available at: https://portal.helcom.fi/meetings/FISH-M%206-2018-552/MeetingDocuments/Outcome%20FISH-M%206-2018.pdf

structures that presently are visible. It is also possible to predict the future development of the watercourse to some extent and to draw conclusions about what measures would improve the conditions. For this to be possible, however, experience and competence of the person who carries out the survey is required. A shortcoming in these experiments has been that the staff performing the surveys had not received sufficient training of the RHS method. Particularly, interpretation of the results has been difficult to implement. In addition, many parameters are based on a subjective assessment of structures and functions which will increase variation among field workers and reduce accuracy of the results. Accuracy may increase with intercalibration and the staff having experience of many different types of watercourses. The method has large potential to explain the causes of the environmental problems seen and to generate proposals for measures that provide the desired results in the long term. It is also useful for performing the classification of the hydromorphological quality factors according to the Water Framework Directive. But more education and experience than was offered within the RETROUT project would be required for the method to be used successfully.

4.2.2 Synthesis from THS testing experiences

The Trout Habitat Score was tested and compared to electrofishing results in Latvia, Estonia and Poland (for detailed results of the Polish study, refer to www.retrout.org). In Latvia, two reduced versions of the THS were also tested: an expert classification without any measurements (only relying on the experience and competence of the surveying staff) and scores calculated from data in the standardised Latvian electrofishing forms.

In Estonia, it was found that the model could be reduced to include only substrate class and river width to get a significant relationship. Also, in Poland and Latvia there were clear relationships between THS and parr densities. In Latvia, the expert classification gave as good correlation as the original model, but the THS calculated from the electrofishing forms was not significantly correlated with electrofishing data. If this result prevails in extended tests, studies including older electrofishing data with only basic habitat information will be of less value.

In both Poland and Latvia, the potential parr density as calculated based on the THS score (Function 1) was significantly larger than the observed data. This indicates that the present model has low predictive power of the exact number of parr per 100 m^2, or more plausibly, that the sea trout population in these rivers for some reason do not reach to the potential maximum that the river habitat should sustain. It is possible that including more variables in the model, e.g., presence of other species, could increase the predictive power.

One of potential problems acknowledged commonly was that all the parameters used in calculations have the same power, although some factors are clearly more relevant than others. For instance, stream velocity is likely to be a limiting factor for trout populations, but they have only a limited effect on the THS value. Width and substrate were the best predictors of trout parr density, which perhaps also should be accounted for in the model by e.g., weighing the effects (or scores) of the variables differently. In general, small streams with gravelly bottom are most suitable for trout. Based on all above, it would be possible to simplify the trout habitat score further by focusing only on the most relevant parameters, width and substrate, especially if all parameters are not possible to assess. However, there is still large unexplained variation wherefore more studies are needed.

THS is useful as one of the tools to study sea trout rivers. THS is a simple method to apply and gives a good picture of the suitability of a river stretch as a trout habitat. If there are large differences between observed and predicted parr densities, i.e., if the recruitment status is low (ICES 2015), it could indicate deterioration in some part of the environment that is important to sea trout or indicate a general decline in the spawning stock due to, e.g., fishing mortality.

4.2.3 Synthesis from EF&PDE testing experiences

Comparison of electrofishing protocols

During a workshop in Klaipeda, Lithuania, differences, similarities, and the need and possibilities for harmonisation of the electrofishing protocol among the RETROUT countries were considered. Table 4 summarises the comparison.

The workshop considered whether to a) accept that catchability slightly differs in different countries due to somewhat varying protocols b) to harmonise the used protocols or c) to use a catchability model which takes the different aspects into account in order to allow for comparing the results of varying protocols between countries. The workshop concluded that the current national electrofishing practices and protocols will continue to be used, but that a method to compare the results would be beneficial. Thus, a harmonisation of electrofishing methods among countries is possible but not considered as necessary at this stage.

The differences in electrofishing protocols between the countries are not very substantial, with the varying number of nets in water and number of sweeps being the two most important aspects. The number of nets used may affect the catchability; with more nets, more fish will be caught. In Poland, Latvia, and Lithuania sometimes only one sweep is used, which gives a qualitative estimation. A rough quantitative estimate may be given by assigning a standard value to the catchability coefficient, but the results will be less robust compared to multi-sweep samples. To evaluate this effect the difference between one and three swipes was tested in Latvian rivers. The workshop concluded that the current national electrofishing practices and protocols will continue to be used, but that a method to compare the results would be beneficial. Thus, a harmonisation of electrofishing methods among countries was possible but not considered as necessary at this stage.

Table 4. Comparison of attributes in the national electrofishing protocols

Attribute/country	**Lithuania**	**Latvia**	**Estonia**	**Sweden**	**Poland**
Gear	backpack	Generator with 50 m cable	backpack	Generator with 50 m cable	Backpack or generator depending on site
Team size	2 (1 net (anode))	2 (1 with a net and bucket)	3 (2 nets)	2 (anode net, bucket and cable)	2 (one with anode and net, 1 with bucket and net)
Number of sweeps	1 to 3, it is depending on the density (usually 2)	1 (3 in Salaca river), 3 in every river until 2012	2	3	1
Calculus	Zippin (modified by Bohlin)	–	Zippin	Zippin	No

Attribute/country	Lithuania	Latvia	Estonia	Sweden	Poland
Stretch length	Adapted to the site (60–120m)	100 m or less if 350 m2 for 3 sweeps or 500 m2 for 1 sweep is reached	Adapted to the site, typically 200 m^2	30–50 depending on the site	100–1000m depending on the site
Time between sweeps	30–45 minutes	30 minutes	30 minutes	30–60 minutes	-
Release of caught fish	After each sweep downstream	After each sweep downstream	After 1st sweep downstream	Retain in cage	After fishing
Length[8]	SL, TL	FL for salmonids only) material analysed in laboratory also TL), TL for all other species	TL	TL (measurements taken within pipes)	2 classes (below or above 15 cm)
Weight	100 first trout, 1 g accuracy	Weighted in the lab (for a sub-sample)	100 first from a given age group, 0.1 g accuracy	SLU does not use weight data	Not used in the European Fish Index, but data of all individuals from each species are sometimes collected
Age determination	Yes (scale samples)	By the length classes (for	Yes (scale samples)	No	No
Other species	Not recorded, species list only	Yes	Yes	Yes, length structure	Yes
Timing	1.8. –15.9.	20.7 –20.8. for salmonids. May–September for other species	15.8–30.9	1.8. –beginning of October	1.8–31.10
Data accessibility outside	By request	By request	By request	Open access	
THS in use	Yes	No	Simplified	Yes	By request
Note	Data to ICES WGBAST	Not looking for best spots but zigzagging. Same monitoring sites every year.			No

Summary of the national EF&PDE testing outcomes

The electrofishing and parr density estimation were tested in Latvia, Poland and Estonia. In Latvia, estimates based on one and three electrofishing sweeps were compared. When only one sweep was done, the parr density is estimated by dividing number of parr caught in first run with coefficient 0.6 (for 0+ age class), in contrast to the three-sweep alternative where PDE was done by means of the

[8] SL – Standard Length, FL – Fork Length, TL – Total Length

Zippin method (1956). In Poland and Estonia only fishing with three sweeps was conducted and the results were used to compare observed values of parr density to ones estimated from the THS results to obtain an index of recruitment status (see section 4.2.2).

The parr density estimates obtained by one and three electrofishing sweeps differed especially when considering in individual monitoring sites. In general, carrying out three sweeps and estimating the parr density according to the Zippin (1956) gave a better estimate compared to one sweep only. However, there is a trade-off between accuracy and the number of rivers that can monitored. If the rivers were to be monitored with three sweeps, fewer rivers could be monitored. Averaged over all studies in the country, the two methods were equal. If the purpose of the electrofishing programme is to get an estimate of the trout production over a larger area, one sweep could be used. However, when monitoring is used to draw conclusions of the conditions in a particular river, one-sweep electrofishing is of less value.

5 Lessons learnt from the RETROUT study on river restoration success factors

The RETROUT project carried out a joint evaluation of completed restoration projects. With the aim to understand factors that may lead to either success or failure of restoration projects, a study containing information from a large number of past restoration projects in the Baltic Sea region was undertaken. Due to the lack of good follow-up studies, there are many lessons not learned or shared from already performed restoration projects. To address this, information on past restoration projects was requested from the RETROUT project partners, HELCOM contracting parties, and other direct sources. Different types of restoration projects were evaluated, based on gathered data on specific project features such as environmental background settings, costs, construction time, stakeholder involvement, and project difficulties particular successes. The study has been published as a separate project report providing a comprehensive account of approaches used and results gained (Singh et al. 2021). The gained results on the river restoration success factors, contributed to the development of the Baltic Sea river restoration best practices (Chapter 7).

5.1 General features and results from the study on river restoration success factors

In this study (Singh et al. 2021), data from 97 past river restoration projects located in 74 coastal rivers in the Baltic Sea region were received, compiled and analysed for factors contributing to success or failure of a restoration project. Most projects originated from Estonia (36 projects) and Lithuania (24 projects). From Latvia, Sweden, and Poland and there were 12, 10 and 9 projects respectively, from Denmark 4 projects, and from Russia and Finland one project each. Ninety-one of the past projects were 'completed' projects and 6 were 'non-realised' (i.e., planned but never finalised). Most completed projects were classified as 'success' (52/91), while 19 were classified as 'partial success, 11 as 'failure', 9 projects as 'not known'. Regarding overall aim of the restoration projects studied, the following were prominent: Improvement of fish populations by facilitating upstream and downstream migrations for improved natural reproduction, restoration of other biological diversity, enhancing recreational value, revival of cultural heritage, and other kinds of stakeholder interests. The included restorations projects concerned several different restoration measures (Table 5) used for solving the respective environmental problems and achieving the project aims. The main restoration types included were removal of migration obstacles, construction of fish passes, and river habitat improvement. The included restoration activities varied between short- and long-term, and site-specific to river-wide. Depending on the projects they involved local and, regional and national authorities, non-governmental organisations, citizens and the private sector. The costs of the included projects varied between 30 000 and 5 000 000 €.

Important specific lessons learned for project success concerned the importance of: proper design of fish way solutions; a comprehensive project approach in restorations; careful choice of actions and targets as well as monitoring and project evaluation; and maintenance of good water quality; and finally applying the simplest possible measures to maximise ecological effect while minimising negative effects for other interest. Important factors noted as thwarting achievement of restoration goals were: wrong technical design and implementation; and conflicts of interests among stakeholders and resultant difficulty in stakeholder acceptance especially in situations with multiple interests. In general, the importance of stakeholder management emerged from many of the analysed projects.

A smaller sample of river restoration projects (n=16) was selected for detailed interview-based case studies. The interviewed case studies included projects of different temporal and spatial scales, and of the all the groups 'success', 'partial success', 'failure', and 'non-realised'. The interview data were compared across countries to extract the most important factors leading to success or failure of the restoration projects (Table 6). The factors were divided into two broad categories: *context-based* and *process-based*. The former concern the context in and about which the project is designed and implemented, while the latter concerns the process adopted for planning, designing, implementing and undertaking the post-implementation phases of the project. The study showed inter alia that sufficient knowledge and understanding of the ecological challenges affecting the fish population is a centrally important factor for success. Other emerged factors were e.g., long-term political support, adequacy and long-term availability of funds, efficient project team and teamwork, and importantly, successful stakeholder involvement and consensus building.

The usefulness of the study on river restoration success factors to provide input for river restoration best practices, stems from the analyses of a considerable number of past restoration cases as well as a number of in-depth stakeholder interviews. By including a broad selection of different types of restoration projects (regarding problem, measures, extent, funding, etc) from most of the Baltic Sea coastal countries, the outcome of the study effectively covers various aspects of practices in river restoration projects and thus centrally contribute to the development of best practices for river restoration projects in the Baltic Sea region.

Table 5. Restoration activities concerned in the studied projects

Main category	**Sub-category**
Removal of migration obstacles	Dam removal
	Reconstructing culvert
	Removal of beaver dam
	Removal of culvert
	Removal of other man-made obstacles
	Removal of vegetation
	Removal of wood debris
Fish pass	Nature-like fish pass
	Technical fish pass
	Fish lift
River habitat improvement	Changing hydrology
	Improving water quality
	River habitat restoration, including spawning grounds
	Wetland
	Afforestation
Fish transport	Fish transport
Fishing rules	Fishing rules
Stocking	Stocking

5.2 Context-based factors

5.2.1 Ecological context

The ecological context is the most important driver of a river restoration project. The ecological challenge or the problem in the river needs to be identified and known.

A successful restoration project requires holistic knowledge of the river ecology and pressures affecting it on a whole-river scale, and understanding of the specific ecological challenges that adversely affect fish populations. This includes knowledge about all migration obstacles, quality of specific river habitats, water quality and quantity issues, and any other related ecological problem in the river/ basin that can impact fish populations. Knowledge on these aspects at a wider spatial scale is desirable, as the neglect of the ecological conditions upstream or downstream a restoration site can adversely impact the project outcomes.

5.2.2 Political context

Policies and legal frameworks in force can strongly steer ecological restoration works at local, national and regional levels. This sort of policy context can thus play a major role in determining the sustainability and success of a river restoration project. Three following important factors in the policy context were identified.

Relevant policy and legal frameworks at local, national and/or regional scale

Existence of relevant policy and legal frameworks at the municipal, national or higher levels can help provide long-term support to river restoration projects. Cohesive policies and regulatory frameworks that support integrated long-term solutions are especially important. At a regional or international scale, common legal/policy/action framework, such as the EU WFD or the BSAP, can help by providing a common set of principles and practices. This is an important factor especially for supporting restoration in rivers that are transboundary in nature. Natura 2000 regulations and national Environmental Impact Assessment (EIA), or other national or local policy frameworks or legislation might facilitate the success of a river restoration project by setting legal requirements and obligations for stakeholders carrying out activities that cause pressure to the river and its ecology, for instance making the provision of fish passes compulsory for dam owners.

Nature of political support vis-à-vis the proposed restoration

Active long-term political support from various levels – municipal, national or regional – is a positive factor for sustainability of restoration projects. Examples of potential benefits include long-term institutional support, better coordination with different stakeholders and more stable financial resources. On the contrary, private or non-governmental efforts are always potentially exposed to higher risks.

Political scale involved – local, national, international

The political scale is important in determining the fate of restoration projects. This factor is important because accordingly support can be drawn from or any existing barriers addressed on the political scale concerned. Financial, legal and administrative setups can all be defined by the political scale. Also, identification of stakeholders is determined by this factor. A successful restoration project requires integration and coordination between concerned agencies at the different political scales – such as municipal and county or ministries of national governments, etc. In the case of transboundary projects, functioning coordination and cooperation of national (and other agencies) at other relevant scales also plays a decisive role in determining project success.

5.2.3 Economic factors

Understanding the economic context is important for designing effective restoration projects. Two important factors were identified; economic interests affected by the restoration and financial resources available to the project.

Economic interests supported or hampered by the restoration

A proposed river restoration project can affect the economic interests of stakeholders variously. Basically, it can be an economic activity or interest that directly or indirectly is affected either positively or negatively by the restoration venture. It can be e.g., loss of ability to operate a HPP or decrease of its rentability, property depreciation (or value increase), or lost or gained value for tourism attraction or for recreation and through that on related economic interests. It can also be an economic interest on a more abstract or larger scale, related e.g., to the expected increase of the economic value of a fish stock benefitted by the restoration.

Financial resources available to support the restoration

Availability of adequate funds on a long-term basis is essential for ensuring sustainability and success of any river restoration project. Not only are these required for the phase of implementation, but also for any pre-project preparations and post-project activities to assess sustainability. For instance, insufficiency of funds to fulfil a legal required EIA, can prevent a project to be realised. Thus, a successful restoration project requires adequate pre-secured funds allocated to all project phases and for the whole project duration.

5.2.4 Social and cultural factors

Social and cultural factors are often overlooked when planning and implementing river restoration projects. Social factors can include aspects like multiple owners, interests and interest groups, jurisdictions, values, and public involvement. Culture can include aspects like beliefs, values, practices, and artifacts of a social group. Different stakeholders may hold different values and interests in the project. River restoration is an adaptive problem which is socially and ecologically complex, and where the solution is not actually 'known'. Two main social and cultural factors that can influence the fate of a river restoration project were identified as stakeholder interests and cultural/historical/other values.

Stakeholders and their interests around the proposed project

Projects where stakeholders and their interests around the project are identified and included from the beginning, usually perform well. In contrast, projects with conflicting stakeholder interests or lack of mutual trust might more often fail or never be realized. A successful restoration project requires early stakeholder consensus, cooperation and a relationship based on trust and mutual support. It is important to make an assessment of conflicting or diverse interest early in the project planning process and act appropriately to resolve them and making an effective plan.

Cultural/historical/other values connected to the site of proposed restoration

The location of a proposed river restoration measure may be closely in conflict with the cultural, historical, recreational, environmental or other values upheld by the local. If not acknowledged and solved the restoration project may fail to take off altogether. When no conflict exists between the restoration measure and these values and stakeholder interests, the project usually does not face any opposition.

5.3 Process-based factors

5.3.1 Technical dimension

The visible part of a river restoration project is the technical/practical solution implemented to reach the ecological goals. Several previous publications on technical/practical interventions for river restoration are available (see Chapter 2). For instance following measures and interventions are commonly acknowledged and mentioned: reducing excessive sediment input, improving water quality, removal of migration barriers, hindrances and other physical obstacles or unfavourable artificial structures, installation of a fish pass solution for up- and downstream migration, removal of bank fixation, re-meandering straightened river stretches to natural or near-natural shape, and recreating gravel beds, riffles and pools for spawning rearing and holding habitats for fish. All these restoration measures are known to have positive impacts for strengthening fish populations. Three important process components were identified as the selection of the restoration measure, the technical designing, and the implementation, operation and maintenance of the intervention.

Selection of the restoration measure

Selecting the most appropriate restoration measure is one of the most central issues in a restoration project. Achieving the optimal solution with the resources available can be challenging as the ecological objectives need to be balanced with other values and stakeholder interests. A successful restoration project requires the selection of the restoration solution to be made carefully, following a thorough assessment of all relevant context-based factors. This process is often influenced by some of the other process factors, such as the planning (e.g., preparatory work) or social factors (e.g., inclusion of stakeholders from early project stages or achieving their consensus on the selected measure).

Technical designing

After selection of the most appropriate measure – ecologically and socially – the design needs to be prepared with great care and diligence to be effective in operation. To achieve this, a competent and experienced designer is needed. Optimally also, the designer needs not only an understanding of what sort of solution need to be designed with all the technical parameters given, but importantly should understand the (ecological) aim and purpose of the chosen solution to be designed. A successful restoration project requires a good technical design and designing process, while sub-standard technical design can be an important cause for project failure.

Implementation, operation and maintenance of the interventions

Based on the agreed design, the project needs to implement it to be operational, and ensure its efficient operation as well as upkeep and maintenance in the long term. To be successful the implementation needs to be efficient and correct, leading to high-quality end result that corresponds to the agreed design. This can be facilitated by using competent and experienced entrepreneurs or other operators, such as e.g., volunteers. When the restoration measure is implemented, likewise correct and efficient operation and maintenance are important. For instance, if not enough water is directed to a fish pass it will not function. Further, river restoration efforts take time to show impacts, and thus require continuous monitoring of the technical and ecological functionality and corresponding adaptive maintenance measures to secure success.

5.3.2 Project processes

Planning is a key process in any project, that must be conducted with great caution. A number of important planning dimensions need to be considered while evaluating the factors underlying success or failure of a river restoration project. Following planning, efficient and effective implementation of the project and thereafter regular follow-up activities. Important emerged factors related to project processes were identified as related to background information and preparatory assessments, to the nature of the plan and process adopted, and to the post-implementation phases of the project.

Preparatory assessments

Planning of a project must be preceded by necessary preparatory exercises. These can include environmental, economic and social/cultural assessments. Environmental background surveys inform on the nature of the hydro-morphological and ecological conditions and problems, as well as its causes and potential solutions, and are the starting point for formulating the restoration intent. Environmental or social impact assessments analytically address the baseline situation important for nature values and the local communities and stakeholders, and how they are expected to be affected by the intended restoration activity or solution. Depending on the features of the project and the national/regional legislations, Impact assessments might be either mandatory or voluntary. Project planning based on adequate and appropriate preparatory work, including background surveys and impact assessments, is better informed and thus has higher possibilities of success.

Nature of the plan and process adopted

The nature of a restoration project and its plan can be long- or short-term, site-specific or watershed-based, have specific or multiple goals, etc. A long-term integrated approach, preferably at watershed scale, combining more than one ecological aspect is an optimal option for the projects holistic impact and sustainability. Further, regarding the planning process, important aspects include project origin in good preparatory work and rational decisions made with participation of stakeholders. Incorporation of local cultural, historical, recreational, or other values or preferences in the restoration plan and design can serve as a positive factor, neglect of which can lead to project failure.

Post-implementation phases

A good project must also include resources and strategies for monitoring and evaluation of the effectiveness and impact of the restoration intervention on the target indicator, in practice often, the fish population to be improved. Monitoring and evaluation are important to enable, if need be, corrections, adaptive maintenance, and long-term sustainability of the restoration intervention. Also, long-term impacts can be ascertained only after proper evaluation based on long-term monitoring. Thus, a project that includes all the project cycle phases from initiation to post-implementation activities is more likely to be sustainable, and hence successful, than a project that is not as comprehensive.

5.3.3 Social factors

Social factors comprise a wide array that ranges between aspects that concern the project internally to those that connect to the external systems and processes. From this study, four important social factors were identified, and regarded the project team, decision making, and stakeholder management and engagement, and project communication.

Project team

The project team broadly consist of all those who directly contribute to the different project phases. It can have members from the implementing agency alone, or also include external people as experts, entrepreneurs, social organisations, etc. Even key stakeholders may be included. A cohesive project team comprises an array of relevant actors possessing necessary knowledge, experience, and skills, including good leadership and coordination skills. Especially, capacities as good leadership and genuine passion and motivation for nature conservation and river restorations contribute to project success. Willingness and diligence to work on part of management group as well as continuous guidance to the implementing entrepreneurs and right competence and experience within the implementing group are further positive emerged factors for successful restoration projects.

Decision-making process

Decision-making is a process which occurs repeatedly in any project through different stages. Important aspects of decision-making relate to how decisions are made, who exercises the authority, and who contributes, on which part and to what an extent. Projects having participatory decision-making with stakeholder consultation in arriving at strategic decisions tend to be successful. Within the project team too, a participatory style of decision-making while implementing projects seems to have promoted success.

Stakeholder management and engagement

Identification of relevant stakeholders and their interests is an important initial step in a project. Thereafter, it is important to address any potential or existing conflicts, and to stakeholder confidence, acceptance and participation. Stakeholders management thus involves conflict solving, coordination, and active stakeholder involvement, importantly through open and double-sided communication. A failure in stakeholder management can be detrimental for the fate of the project. A relationship based on confidence and trust between the project team and the local stakeholders (including the community) can create a sense of ownership to and a collective responsibility of the restoration project and the river environment in general. Successful multi-stakeholder management, with involvement of experts, municipality, environmental groups, anglers and citizens can create positive and beneficial added values to a project (such as various voluntary support) beyond the mere acceptance received. Also, effective engagement of external stakeholders can help in post-project monitoring.

Project communication

Finally, communication is an important project process that may heavily influence the project fate. Clear, regular and effective communication is essential within the project management team as well as with the external stakeholders, contribution at many levels to a successful project. Good coordination within project teams itself reflects effective internal communication. Effective double-sided communication with local stakeholders for instance can create inspiration and trust, making the restoration work a collective responsibility for the community. Also, stakeholder communication and information dissemination early in the project help minimise the risk of opposition. Conversely, ineffective and delayed communication regarding benefits of the restoration for nature and fish can cause lack of acceptance and ultimately project failure. A good communication plan and a practice of open and transparent dialogue are fundamental for achieving functioning communication throughout a restoration project.

5.3.4 Financial planning and resources

Adequacy of funds is an important factor promoting success. This involves securement and allocation of funds throughout the different project phases. To facilitate this and to make a project efficient and effective, good financial planning is importantly needed. In general, allocating funds for monitoring and post-implementation evaluation is unfortunately often a rare praxis, as the emphasis mainly is on project implementation. Also, for instance, insufficiency of funds secured for undertaking a mandatory environmental impact assessment might ultimately lead to non-realization of the project.

Table 6. An overview of factors important for success of river restoration projects (adopted from Singh et al. 2021)

Nature of factor	Dimension	Criteria	Factors promoting project success
Context-based	Ecological	Ecological challenge(s) to address, the spatial scale and overall ecological status of the river stretch	Holistic knowledge and understanding of the ecological challenges adversely affecting fish populations, including water quality and quantity issues, and any other related ecological problem in the river/ basin
	Political	Relevant policy and legal frameworks at local, national and/or regional scale	Cohesive policies and legal frameworks that support integrated long-term solutions
		Political support vis-à-vis the proposed restoration	Long-term political support
		Political scale involved — local, national, international	Integration and coordination between different political scales involved
	Economic	Economic interests hampered or supported by the proposed restoration	Promotion of common economic interests
		Financial resources available for the restoration	Adequate and long-term availability of funds
	Social and cultural	Stakeholders and their interests around the proposed project	Consensus, cooperation and relationship based on trust and mutual support among stakeholders
		Cultural/historical values connected to the site of the proposed restoration	Recognition of cultural/historical values at the proposed restoration site
Process-based	Technical	Selection of the restoration measure	Choice of the most appropriate solution, based on an integrated context-analysis
		Technical designing	Ensuring effectiveness of the design
		Implementation and maintenance of technology	Effective implementation and long-term maintenance
	Project processes	Preparatory work – hydrological, environmental or other scientific assessments	Completion of preparatory studies or pre-assessments for baseline data, and project design
		Nature of the plan – e.g., long/short term, site-specific/watershed-based, specific/multiple goals	Long-term integrated approach, preferably at watershed scale, combining multiple ecological goals
		Post-implementation phases included in the project – monitoring and evaluation	Plan comprising all project cycle phases – implementation, monitoring, evaluation
	Social	Project team/actors – composition, roles, skills, personal attributes, leadership, coordination, etc.	Cohesive team comprising an array of relevant actors possessing necessary knowledge and skills, including good leadership and coordination skills
		Decision-making process	Participatory decision-making, inclusive of stakeholders' perspectives
		Stakeholder management and engagement	Stakeholder involvement in all project phases, and efforts at consensus building
		Project communication within team and with stakeholders	Effective and regular communication with stakeholders and within team
	Financial planning	Allocation of funds for every project phase	Adequate funds allocated for supporting every project phase

Nature of factor	Dimension	Criteria	Factors promoting project success
	and resources		

6 Summary outcomes from RETROUT river restoration demonstration projects

The RETROUT project demonstrated different river restoration practices through a number of real restoration projects in Baltic Sea rivers. The purpose of the restoration projects was to demonstrate solutions for improving river habitats and connectivity to enhance and secure viable sea trout populations. The included projects were driven, supervised or observed by the responsible national RETROUT project partners. The demonstration projects are a result of international peer learning and basin-wide research and can serve as examples and guidance for future river restoration projects.

A total of 15 river restoration projects in the partner countries were included. The projects consisted of fish ways installations, habitat restorations, water quality improvement, and dam removal plans. All demonstration projects were documented from start until finishing in form of process documentation including all relevant proceedings. After completion, each project was evaluated, and the experiences and documented process stages have been compiled to case specific restoration project reports. The restoration project reports addressed and included to applicable parts following aspects: basic project information, background account, project initialisation, planning phase, preparations and implementation, and evaluation of the project process and success. The full restoration project reports are compiled and available in the Supplementary report[9]. Documented experiences of the restoration project process, including identified success factors and lessons learned, contributed to the development of the Baltic Sea river restoration best practices (Chapter 7).

6.1 General experiences and lessons learned from the demonstration cases

A total of 15 restoration projects in 11 coastal rivers from Estonia, Latvia, Lithuania, Poland, and Sweden were included (Figure 2), addressing a number of different problems affecting sea trout and other migratory fish populations. In Estonia, 6 restoration projects were included, all related to restorations of migration obstacles. The responsible project partner for Estonia was the Estonian Marine Institute at the University of Tartu. In Latvia, the restoration activity concerns planning and building a fish pass in Rīva river around the remains of an old paper mill dam. The responsible project partners for Latvia were Kurzeme Planning Region and Ventspils Regional Municipality, with support and expert supervision from BIOR. In Lithuania, two restoration projects took place in river Smiltelė/Smeltale. The projects concerned measures for water quality and habitat improvements. The responsible project partners for Lithuania were the Administration of Klaipeda District Municipality and Klaipeda University. In Poland, the restoration project concerns a fish pass construction around a weir in Reda river. The main implementing responsibility in this project is with the local and regional water management authorities, while the role of the RETROUT partner Maritime Institute at Gdynia Maritime University was to observe and monitor the process. The project is implemented with external funding outside of the RETROUT budget. In Sweden, 5 restoration projects were included, concerning habitat restorations and a fish pass construction. The responsible project partners for Sweden were the County Administrative Board of Stockholm and

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[9] The Supplementary report is a compilation of the RETROUT river restoration case reports. The report is accessible via HELCOM publications page. The direct link to the report is: https://helcom.fi/wp-content/uploads/2021/03/RETROUT-River-Restoration-Demonstration-Case-Reports_v.4.pdf

Haninge municipality (in one case). The Swedish restoration measures were implemented with funding outside of the RETROUT budget.

Although in many of the restoration demonstration projects final post-implementation evaluation of the project process and success have not yet been completed (for the cases were applicable), the documented experiences provide important lessons learned from the projects. These lessons can concern any of the project phases optimally identifying factors contributing to project success or failure. Specifically, these factors may relate to the project process (management, planning, implementation, etc.), the primary ecological objectives, secondary objectives such as provisioning recreational or maintaining cultural heritage values, or to stakeholder matters, for instance.

A key summarisation of the projects is given in Table 7. The problems addressed in the different restoration projects all concerned suboptimal conditions for migratory fish and other river biota, consequently restricting production capacity of the river for target salmonid populations. Specifically, the addressed problems included impaired or blocked fish migration possibilities due to dam and weir constructions, deficient habitat conditions for spawning and rearing, and generally poor river water quality, all common issues in rivers and stream waters. The solutions developed and applied to overcome these problems contained: plans for partial to complete dam removal with necessary enforcement of riverbanks; plans and as well as building of different types of fish pass solutions; adjustment of a problematic culvert for improved connectivity; improvement and restoration of river habitat structures and complexity by addition of gravel, stones, and logs, and by planting of trees along the riverbank; and restoring a wetland sedimentation pool for improved nutrient retention and cleaner water. All solutions applied, somehow concerned improvement of migration possibilities or habitat conditions for migratory fish, especially sea trout. Depending on the purpose and nature of the project, the scale and budget varied from a small culvert and habitat improvement of a few thousand euros up to large multimillion dam removal plans for restoring the characteristics of entire river valleys.

Depending on the project, different types of lessons were learned. In some of the projects these concerned more specific technical aspects, while in other cases more general project process matters were raised. The technical type of lessons learned included, e.g., the prioritisation of full removal of migration obstacles if possible, from the viewpoint of other than ecological interests. In situations where the removal of a barrier was not possible, a fish pass resembling a natural channel as closely as possible was to be preferred. In habitat restorations, technical lessons learned included, e.g., that striving for high structural complexity through strategic addition of gravel, stones, boulders and logs is preferable. Also, it was found important to consider seasonal variations when planning and designing measures. Regarding the project process factors, several important aspects emerged. Public ownership of the restoration site (land, water and/or constructions) and active involvement of concerned public authorities (State, County, Municipality) in the restoration project facilitate a smoother administrative procedure and can enable the most optimal long-term restoration solution to be taken. A restoration result can usually be only as good as the design, on the other hand, even the best design can be ruined by poor implementation. Thereby, thorough planning and use of an experienced and competent entrepreneur simplify the process and ensures high quality. Importantly, early and continued stakeholder involvement and active conflict solving were important for finding compromise solutions and reaching consensus. Additionally, transnational learning and sharing of knowledge, project adaptability to new situations, as well as sufficient funding and budget flexibility emerged as important factors.

The usefulness of these demonstration cases to provide input for river restoration best practices, stems from the first-hand information of experiences and lessons learned from concrete, documented projects, covering a variety of different types of projects (scale, aims, budget, legal frameworks, etc.) and restoration measures (dam removal plans, fish passes, habitat restorations, water quality improvements). These demonstration cases also have given insight in country-specific practices and valuations regarding rivers and restorations. Conversely, the limitation of using input from these restoration projects in this context relate to difficulties in comparability due to different project characteristics and documentation practices. Also, demonstration of good restoration practices, as was the general objective of these projects, would have required a common agreement of what constitute good practice before the start of the projects, while a lack of such common understanding makes it a challenging task overall due to cultural and country-wise differences in views and emphases on the value and role of rivers and different competing interests related to them.

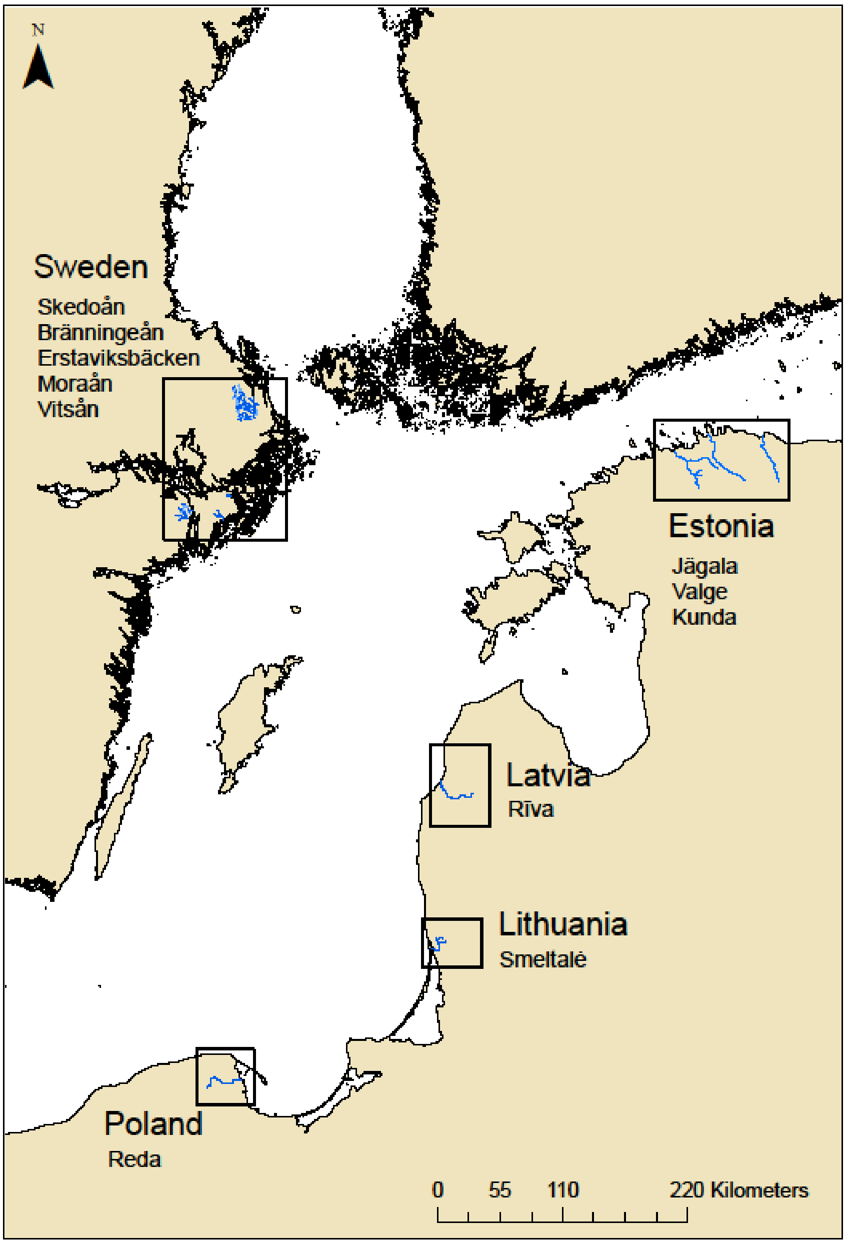

Figure 2. The locations of the RETROUT river restoration demonstration cases.

Table 7. A key summarisation of the restoration demonstration projects

Country	River and restoration site, year	Special characteristics	Ecological problem to be addressed	Restoration project	Lessons learned
Estonia	<u>Valgejõgi</u> Kotka dam	- Mixed sea trout and salmon populations. - One of two remaining man-made migration obstacles in the river.	Migration hindrance in form of an old dam, and consequently poor sea trout and salmon populations.	<u>Type: Dam removal</u> - Planning of restoration project and provisioning of designs for and evaluations of different solutions for dam removal. - Two alternative solutions were produced: 1) a simpler design including dam removal and bank enforcement (cost estimate ~70K €). 2) a more elaborate design including dam removal and creation of an artificial rapid upstream of the dam site (cost estimate ~390K €).	- Full removal of the dam was considered the most optimal solution. - Public ownership of the dam would enable the most optimal long-term solution. - The major benefit of a simpler design compared to the more elaborate design was the considerably lower price.
Estonia	<u>Valgejõgi</u> Nõmmeveski dam	- Mixed sea trout and salmon populations. - One of two remaining man-made migration obstacles in the river.	Migration hindrance in form of an old dam, and consequently poor sea trout and salmon populations.	<u>Type: Lowering of dam hight</u> - Planning of restoration project and provisioning of a design for and evaluations of a solution to overcome the migration obstacle without full dam removal. - One plausible solution was produced: lowering of the water level through excavations at the base of the dam, and creation of an artificial rapid downstream of the dam (cost estimate ~220K €).	- Full removal of the dam was considered not possible due to a bridge in use attached to the dam construction. - Public ownership of the dam would enable the most optimal long-term solution. - Solutions including dam removal and/or rebuilding the bridge constructions were considered too expensive. - The produced solution would provide free fish migration.
Estonia	<u>Kunda</u> Kunda lower HEP (dam)	- Wild and natural salmon and sea trout populations. - Lowest of the four dams in the river. - The dam is a designated culturally valuable object.	Migration hindrance in form of an old dam, and consequently restricted production capacity of the river for the salmonid populations.	<u>Type: Different solutions to overcome migration obstacle (dam)</u> - Planning of restoration project and provisioning of a design for and evaluations different solutions to overcome the migration obstacle. - Three alternative solutions were produced: 1) partial opening on the left side of the dam and building of a new river channel with a concrete wall for enforcing and stabilising riverbank, and a bridge across the new channel (cost estimate ~2.59M €). 2) removal of the main body of the dam (except turbine building) to lower water level to the original and allowing the creation of a 100 m long rapid area (cost estimate ~1.04M €). 3) complete removal of dam and constructions to restore the river and the valley close	- At least partial removal of the dam is unavoidable for a viable passage solution. - Public ownership of the dam would enable the most optimal long-term solution. - A most optimal compromise between the environment and cultural values should be found. - The produced alternatives presented solutions from maximising the retainment of cultural values to restoring the river close to its natural state. - The third alternative retains most of the cultural values and provides free passage to all fish and aquatic life.

Country	River and restoration site, year	Special characteristics	Ecological problem to be addressed	Restoration project	Lessons learned
				to its original state (cost estimate ~1.16M €).	
Estonia	Kunda Kunda manor mill (dam)	- Wild and natural salmon and sea trout populations. - Third of four dams in the river.	Migration hindrance in form of an old mill dam, and consequently restricted production capacity of the river for the salmonid populations.	Type: Dam removal - Planning of restoration project and provisioning of a design for and evaluations of a solution for dam removal. - One plausible solution was produced: complete removal of all remaining parts of the dam, enforce the riverbanks, and filling of gravel and boulders in deep pool below the dam (cost estimate ~100K €).	- Full removal of the dam was considered the most optimal solution. - Public ownership of the dam would enable the most optimal long-term solution.
Estonia	Kunda Kunda Aravuse fish farm (dam)	- Wild and natural salmon and sea trout populations. - Fourth of four dams in the river.	Migration hindrance in form of a dam used for a water supply system for a fish farm, and consequently restricted production capacity of the river for the salmonid populations.	Type: Natural-like fish pass - Planning of restoration project and provisioning of a design for and evaluations of a solution for natural-like fish pass to overcome the migration obstacle. - One plausible solution was produced: building of a 130 m long natural-like fish pass on the right side of the dam imitating a natural rapid with two resting pools (cost estimate ~180K €).	- Removal of the dam is not a plausible solution, and therefore a fish pass is needed. - The dam has a water permit, obligation the owner to implement a fish passage solution in near future.
Estonia	Jägala Linnamäe hydropower station	- The river has a natural 8 m high waterfall 4.3 km from the sea. - Natura 2000 area - Historical populations of sea trout, salmon and other anadromous fish have disappeared. - An absolute migration hindrance. - Declared as a culturally valuable object.	Migration hindrance in form of an old dam, and consequently restricted production capacity of the river for the salmonid and other migratory fish populations.	Type: Different solutions to restore the riverine habitat and overcome migration obstacle (dam) - Planning of restoration project and provisioning of a design for and evaluations different solutions to overcome the migration obstacle and restore the river habitat. - Three alternative solutions were produced: 1) to lower water level to pre-dam conditions, part of the dam would be demolished (rest remains intact) and a new river channel built, with a concrete wall stabilising the riverbank and a new bridge across the channel (cost estimate ~6.78M €). 2) removal of the main body of the dam (except turbine building) to lower water level to the original and allowing the creation of a 130 m long rapid area (cost estimate ~2.17M €). 3) complete removal of dam and constructions to restore the river and the valley close to its original state (cost estimate ~2.39M €).	- Natural and cultural values are conflicting, and a compromise is needed. - A fish pass solution next to the dam was deemed insufficient due to limited available space and because a fish pass would not end the water impoundment which is needed to ensure recovery of anadromous fish populations. - River Jägala from the waterfall to the sea is Natura 2000 area, requiring restoration of river and its fauna to achieve good ecological status. - A complete demolition of the dam is not possible due to declared cultural values. - The HEP has a temporary water permit obligating the owner to provide a fish passage solution. - The first alternative retains most of the cultural values at the dam and provides free passage to all fish and aquatic life.
Latvia	Rīva Remains of old paper mill dam	- Wild and natural salmon and sea trout populations.	Migration hindrance in form of remains of an old dam, and	Type: Natural-like fish pass - Complete restoration project, including all phases from planning to	- There were lessons of good cooperation practice learned between customer and service provider as well

Country	River and restoration site, year	Special characteristics	Ecological problem to be addressed	Restoration project	Lessons learned
		- One dam in lower part of the river. - Clear conflict between nature and cultural/tourism interest.	consequently restricted production capacity of the river for the salmonid and other migratory fish populations.	implementation and post-implementation evaluation, concerning a fish pass solution to overcome the migration obstacle. - A natural-like fish pass solution was chosen and implemented (total project costs ~220K €).	as between project partners and stakeholders. - Stakeholder involvement and active conflict solving was important to find consensus. - Transnational learning and sharing of knowledge and experience was important for finding an optimal solution. - A restoration project needs to be adaptable to new information that emerges. - Budget flexibility and availability of additional funding sources was beneficial to secure implementation under changing plans.
Lithuania	<u>Smeltalė</u> Main tributary	- Original strain of sea trout. - A biopond-system established in 1996 to improve the water quality.	Poor water quality, and consequently suboptimal living conditions for sea trout and other river biota.	<u>Type: Bio-pond system</u> - Complete restoration project, including all phases from planning to implementation and post-implementation evaluation, concerning a bio-pond system recultivation for improving water quality. - A solution to clean and fix a non-working wetland sedimentation pool to improve nutrient retention for cleaner water, was chosen and implemented (total project costs *unreported*).	- The restoration activities in Smeltalė river have positively influenced other restoration ventures outside the project.
Lithuania	<u>Smeltalė</u> Smiltaitė tributary	- Original strain of sea trout.	Suboptimal habitat conditions for spawning and rearing, and consequently restricted production capacity of the river for the salmonid and other migratory fish populations.	<u>Type: Habitat improvement</u> - Complete restoration project, including all phases from planning to implementation and post-implementation evaluation, concerning improvement of sea trout habitats. - A solution to restore and improve three spawning and rearing stretches, by e.g., adding of gravel and stones, was chosen and implemented (total project costs *unreported*).	- The restoration activities in Smeltalė river have positively influenced other restoration ventures outside the project.
Poland	<u>Reda</u> Ciechocino weir	- Stocked and natural sea trout population and stocked salmon but with no confirmation about successful natural spawning. - Historical spawning grounds of salmonids.	Migration hindrance in form of a weir, and consequently poor sea trout and salmon populations.	<u>Type: Fish pass</u> - Expert observation and monitoring of the planning and preparatory stages of a restoration project concerning a fish pass solution to overcome the migration obstacle. - Two alternative solutions have been produced: 1) construction of a technical fish pass in the form of a slot fish pass. 2) construction of a fish pass in the form of a stone half-	- Solution 2 is the most beneficial for the environment as it enables migration all sorts of aquatic organisms, it fully meets the investor's requirements, while costs of implementation and subsequent operation are similar to the other alternative. - Solutions with natural-like characteristics is the best way to restore river

Country	River and restoration site, year	Special characteristics	Ecological problem to be addressed	Restoration project	Lessons learned
				timbered ramp along the left riverbank (cost estimate ~1.05M €).	connectivity if the obstacle cannot be removed.
Sweden	Bränningeån Bränninge manor	- Previously stocked, now reproducing sea trout population. - Upstream several migration obstacles. - Lower part of the river at Bränninge manor has high cultural heritage values.	Suboptimal habitat conditions for sea trout spawning and rearing at the lower section of the river due previous removal of boulders and lack of spawning gravel in places, which consequently restricts sea trout production capacity in the river.	Type: Habitat improvement - Complete restoration project, including all phases from planning to implementation and post-implementation evaluation, concerning improvement of sea trout habitats. - A solution to restore and improve three spawning and rearing stretches, by adding gravel, stones, and logs, was chosen and implemented (total project costs ~20K €).	- Early onset and continuation of stakeholder communication is important for acquiring consent and broad support. - Careful planning and use of an experienced entrepreneur simplify the process and secures high quality. - Project team need to oversee all restoration activities. - It is important to design the restoration to have desired capacities and features across the full spectrum of seasonal variations. - Involving schools and the general public in restoration projects through different engaging activities, help creating a better understanding of nature conservation measures.
Sweden	Erstaviksbäcken Erstavik manor	- Original sea trout population. - The first migration obstacle from the sea is a poorly functioning fish pass. - The area around Erstavik manor has high cultural heritage values and is frequently visited by the public.	Impaired connectivity due to poorly functioning fish pass, and suboptimal habitat conditions, consequently restricting production capacity of the river for salmonid and other migratory fish populations.	Type: Renewal of non-functioning fish pass and habitat improvement - Complete restoration project, including all phases from planning to implementation and post-implementation evaluation, concerning renewal of a non-functioning fish pass and improvement of sea trout habitats. - A solution to build a new fish pass of wood with less slope was chosen and implemented, and habitat improvement measures were implemented upstream the fish pass by adding gravel and stones to create spawning grounds (total project costs ~40K €).	- Early onset and continuation of stakeholder communication is important for acquiring consent, compromises and broad support. - Involvement of a competent authority (e.g., municipality) can facilitate the process through (e.g., through relaxation of EIA requirement). - Clear contract should be made with entrepreneurs to avoid financial or other disagreements. - Although a more natural fish pass would have been preferred, the chosen solution is a compromise to also save the cultural heritage values of the environment.
Sweden	Vitsån with Rocklösaån tributary Vitså mill and Tungelsta park	- Mixed sea trout population. - Heavily affected by various human activities. - Extensive need for restoration measures in the entire watercourse.	Suboptimal habitat conditions for sea trout spawning and rearing due to multiple causes, consequently restricting sea trout production capacity in the river.	Type: Habitat improvement - Complete restoration project (with two sites), including all phases from planning to implementation and post-implementation evaluation, concerning improvement of sea trout habitats. - Solutions to create a natural-like river floor similar to the pre-dam state (Vitså mill) and to create spawning and nursery areas, by adding gravel, stones, and logs	- When a dam is removed, the emerging river bed is often not in a natural condition. Experience from restoring the river after a dam removal is much needed.

Country	River and restoration site, year	Special characteristics	Ecological problem to be addressed	Restoration project	Lessons learned
				(both), was chosen and implemented (total project costs ~15K €).	
Sweden	Skeboån Three stretches in the lowermost 10 km of the river	Mixed sea trout population. - Heavily affected by various human activities. - Extensive need for restoration measures in the entire watercourse	Migration obstacle at the river mouth. Suboptimal habitat conditions for sea trout spawning and rearing due to multiple causes, consequently restricting sea trout production capacity in the river.	Type: Habitat improvement - Complete restoration project at two sites excluding follow-up studies, plans for a third site. - Spawning grounds and holding spots, restoration of a multichannel branch Type: Fish pass - Plans for construction of a fish pass, hydrological model to optimise water usage to enable constant flow in the fish pass.	-Restoration activities in public places where a lot of people pass by during the work is a very good opportunity to spread information about river ecology and increase awareness of the importance of river restoration.
Sweden	Moraån Two stretches, one close to the river mouth, one in a tributary	Unique sea trout population, rather strong below a migration obstacle, weak upstream	Suboptimal habitat conditions for sea trout spawning and rearing due to multiple causes, consequently restricting sea trout production capacity in the river.	Type: Habitat improvement - Complete restoration project at the two sites excluding follow-up studies - Spawning grounds and holding spots, restoration of a multichannel branch	-Early stakeholder involvement is a key to success and can help avoiding misunderstandings.

6.2 Country-wise summaries

6.2.1 Estonia

In Estonia, 6 river restoration demonstration cases in 3 rivers were included in the RETROUT project. These were: Kotka dam in river Valgejõgi, Nõmmeveski dam in river Valgejõgi, hydropower station dam in river Kunda, Old Kunda manor mill dam in river Kunda, Aravuse fish farm and hatchery dam in river Kunda, and Linnamäe hydropower station and dam in river Jägala. The Estonian demonstration cases contained the planning phases of river restoration activities such as removal of dams, fish pass solutions, bank enforcement, and building of artificial rapids. That is, within RETROUT, planning of restoration projects including provisioning of designs for and initial evaluations of alternative solutions were carried out for later use, but plans were not implemented. The overreaching idea was to develop detailed plans and design documents that can later be used by the Ministry of Environment or private landowners for implementation. Two designing companies were procured to produce the plans and design documents. All projects were successfully completed and solutions with detailed designs were produced for all cases. The most challenging objects were the Linnamäe hydropower station dam on River Jägala and Kunda lowermost hydropower station dam on river Kunda, because of the large scale of the projects and the conflicting cultural/historical interests present. Stakeholder communication between Estonian Marine Institute (project leader), designers, landowners, Counties and the Ministry of Environment were established and worked sufficiently well throughout all the projects. General lessons learned related much to technical aspects, such that e.g., full removal of a migration barrier is the ecologically the best solution but if not possible for other reasons some other natural-like passage solution is to be preferred. Also, State ownership of the restoration site was seen as beneficial, as it can enable the most optimal long-term solution. And finally, when natural and cultural values are conflicting, effective compromise solutions and consensus seeking is needed.

Kotka dam in river Valgejõgi

River Valgejõgi is about 90 km long and discharges to the Gulf of Finland. Water quality is classified as very good and the river has supported mixed Atlantic salmon and sea trout populations. The Kotka dam is the lowermost of the two remaining man-made migration obstacles in river Valgejõgi. The dam is located 9 km from the river mouth and descends from an old hydroelectric power station. The current hight of the dam is 1.1 m. For anadromous salmonids, the dam is considered difficult to pass, and for other, weaker swimmers, it is considered unpassable. Consequently, migratory fish are restricted from reaching the largest and most productive up-stream spawning areas, and the status of salmon and sea trout is considered poor. Kotka dam is considered nationally a high priority fish migration obstacle, and the long-term objective is to ease the fish migration past both remaining artificial dams to reinstate access to more and better productions areas and improve the populations of salmon and sea trout.

The dam has no valid water permit, and the construction is not considered culturally valuable. It was revealed that the dam is broken and has no active function, neither are there any plans to repair it. As removal is understandably the most effective measure to address the negative impact of a dam on fish migration, and as there were no other conflicting interests, full removal of the dam was considered feasible and the most optimal solution. State ownership of the dam is planned and would enable planning for the most optimal long-term solution.

Based on the initial planning and the prerequisites for the project, two alternative solutions for the dam were designed. The first alternative was to remove the remaining dam constructions and build an artificial rapid upstream the dam. This alternative would provide free passage for all aquatic biota and serve as spawning and rearing area for migratory fish species. The second alternative was to remove the remaining dam construction and to enforce the riverbanks at the dam site. This alternative would enable fish migration across the site. The cost estimation of the second alternative was considerably lower than of the first (72K € vs. 390K €). However, risk of unpredictable riverbank erosion was considered as a concern of this alternative. Environmental impact assessment was found not to be mandatory for the project as the objective is to improve the environment.

Nõmmeveski dam in river Valgejõgi

River Valgejõgi is about 90 km long and discharges to the Gulf of Finland. Water quality is classified as very good and the river has supported mixed Atlantic salmon and sea trout populations. The Nõmmeveski dam is the upper of the two remaining man-made migration obstacles in river Valgejõgi. The dam is located 20 km from the river mouth and descends from an old hydroelectric power station. The current hight of the dam is 1 m. For anadromous salmonids, the dam is considered difficult to pass, and for other, weaker swimmers, it is considered unpassable. Downstream the dam there is a natural waterfall that, however, is passable to at least some salmon and sea trout. Consequently, migratory fish are restricted from reaching the largest and most productive up-stream spawning areas, and the status of salmon and sea trout is considered poor. As migratory salmonids need to pass three difficult obstacles (2 dams and the waterfall) to reach the best and largest spawning areas, the long-term objective is to ease migration past Kotka and Nõmmeveski dams so that the fish only must strain themselves to pass the natural waterfall.

The dam has no valid water permit, the site is not considered culturally valuable, but parts of the construction function as foundation for a bridge actively in use. The wooden parts of the dam are broken but there are or have not been any plans to repair them. The water level cannot be lowered more than 0.2 m without threatening the structural stability of the bridge and building a new bridge was considered too expensive. State ownership of the dam is planned and would enable planning for the most optimal long-term solution.

Based on the initial planning and the prerequisites for the project, one solution was designed. Two openings will be made at the base of the dam, which will lower the water level by 0.2 m. Additionally, an artificial rapid downstream the dam would be built to provide free passage up to and across the dam. The estimated cost was about 220 thousand euros. Environmental impact assessment was found not to be mandatory for the project as the objective is to improve the environment. Salmonid parr density is monitored in the most relevant parts of the river since 2016.

Hydroelectric power station dam in river Kunda

Kunda river is about 80 km long and discharges to the Gulf of Finland. Water quality is classified as good and the river a has wild native Atlantic salmon population as well as sea trout. Kunda hydroelectric power station is the lowest dam of four dams in river Kunda. The dam is located 2.3 km from the river mouth. The current hight of the dam is 8.5 m. The dam is considered a complete migration obstacle for all fish. Kunda HEP is one of three unpassable dams close to each other on the lower part of the river and most of the potential spawning areas for salmon and sea trout are located upstream from all three of them, whereby the production capacity of the river for the salmonid populations is effectively restricted.

The dam is not in operation anymore but has been designated as a culturally valuable object. The dam is located in as steep valley and space for building a non-destructive passage solution around the dam is very limited. It became evident that at least partial removal of the dam is unavoidable for a viable passage solution enabling migration of all fish fauna. State ownership of the dam is planned and would enable planning for the most optimal long-term solution.

Based on the initial planning and the prerequisites for the project, three alternative solutions were designed. The first alternative was to make a partial opening on the dam, and to build a new channel with concrete enforcement on riverbanks and a crossing bridge above. The estimated cost was about 2.6 M €. The second alternative was the removal of the main body of the dam (except turbine building) to lower water level to the original and creation a 100 m long rapid area. The estimated cost was about 1 M €. The third alternative was a complete removal of the dam and constructions to restore the river and the valley close to its original state. The estimated cost was about 1.2 M €. The produced alternatives presented solutions from maximising the retainment of cultural values to restoring the river close to its natural state. The third alternative would retain most of the cultural values yet providing free passage to all fish and aquatic life. Environmental impact assessment was found not to be mandatory for the project as the objective is to improve the environment. Salmon and sea trout parr density is monitored on the lower accessible part of the river.

Old Kunda manor mill dam in river Kunda

Kunda river is about 80 km long and discharges to the Gulf of Finland. Water quality is classified as good and the river a has wild native Atlantic salmon population as well as sea trout. The Kunda manor mill dam is the third obstacle from the sea, 5.5 km from the river mouth. The current hight of the dam is 1.7 m. The dam is considered a complete migration obstacle for all fish. The Kunda HEP is one of three unpassable dams close to each other on the lower part of the river and most of the potential spawning areas for salmon and sea trout are located upstream from all three of them, whereby the production capacity of the river for the salmonid populations is effectively restricted.

The dam is partly broken and has no active purpose. The construction is not identified as culturally valuable, and the dam has no valid water permit. As removal is the most effective measure to address the negative impact of a dam on fish migration, and as there were no conflicting interests, full removal of the dam was considered feasible and the most sensible solution. State ownership of the dam is planned and would enable planning for the most optimal long-term solution.

Based on the initial planning and the prerequisites for the project, one solution was designed. The prepared solution was to remove all remaining parts of the dam, enforce the riverbanks close to the dam, and fill a deep pool below the dam with gravel and boulders. The estimated cost was about 100K €. Environmental impact assessment was found not to be mandatory for the project as the objective is to improve the environment. Salmon and sea trout parr density is monitored on the lower accessible part of the river.

Aravuse fish farm and hatchery dam in river Kunda

Kunda river is about 80 km long and discharges to the Gulf of Finland. Water quality is classified as good and the river a has wild native Atlantic salmon population as well as sea trout. The Aravuse dam is located 50 km from the sea on the upper part of the river and is the fourth and uppermost obstacle in the river. The current hight of the dam is 1.5 m and it is considered a migration obstacle for all fish. Although in size not precisely known, the areas upstream the dam possess potentially valuable spawning habitats, whereby the full production capacity of the river for the salmonid populations is on its part restricted by the barrier.

The dam is part of a water supply system for a fish farm. The dam has a water permit, but no required fish pass solution. Due to the active use of the dam, it was evident that removal of the dam was not possible and instead a fish pass is needed. In the near future the owner needs to secure functioning fish passage.

Based on the initial planning and the prerequisites for the project, one solution was designed. The prepared solution was to build a 130 m long natural-like fish pass on the right side of the dam imitating a natural rapid with two resting pools. The estimated cost was about 180K €. Environmental impact assessment was found not to be mandatory for the project as the objective is to improve the environment. Abundance of resident trout in the upper part of the river is not regularly monitored, whereas salmon and sea trout parr density is monitored on the lower accessible part of the river.

Linnamäe hydropower station and dam in river Jägala

River Jägala is about 120 km long and discharges to the Gulf of Finland. Water quality is classified as satisfactory. The river has a natural 8 m high waterfall 4.3 km from the sea. Historically salmonid and other migratory fish populations existed downstream the fall. Linnamäe hydroelectric power station is the lowest dam in river Jägala. The dam is located 1.3 km from the river mouth. The current hight of the dam is 11 m. The dam is considered a complete migration obstacle for all fish, and as access to the historical spawning areas is blocked, all anadromous fish populations have disappeared from the river above the dam.

The dam serves the needs of the HEP and has a temporary water permit, obligating the owner to secure fish passage. The original parts of the Linnamäe HEP are declared as culturally valuable. River Jägala from the waterfall to the sea is a Natura 2000 area, requiring the river to have good ecological status. It was evident that natural and cultural values are conflicting, and a compromise was needed. Although ecologically the best solution, a complete demolition of the dam was not possible due to declared cultural values. A fish pass solution around the dam was neither possible nor sufficient due to limited space and because it would not end the water impoundment which would be needed to ensure recovery of habitats for anadromous fish populations. Therefore, three alternative solutions were produced with the primary objective to restore the riverine habitat and ensure free fish migration. The first alternative was to lower water level to pre-dam conditions by demolishing part a of the dam and by building a new river channel with a riverbank enforcement, and a new bridge across the channel. The estimated cost was about 6.8M €. The second alternative was the removal of the main body of the dam (except turbine building) to lower water level to the original and create a 130 m long rapid area. The estimated cost was about 6.2M €. The third alternative was a complete removal of the dam and constructions to restore the river and the valley close to its original state. The estimated cost was about 2.4M €. The first alternative would retain most of the cultural values at the dam and still provide free passage to all fish and aquatic life.

Based on the initial planning and the prerequisites for the project, three alternative solutions were designed. The first alternative was to make a partial opening on the dam, and to build a new channel with concrete enforcement on riverbanks and a crossing bridge above. The estimated cost was about 2.6 M €. The second alternative was the removal of the main body of the dam (except turbine building) to lower water level to the original and creation a 100 m long rapid area. The estimated cost was about 1 M €. The third alternative was a complete removal of the dam and constructions to restore the river and the valley close to its original state. The estimated cost was about 1.2 M €. The produced alternatives presented solutions from maximising the retainment of cultural values to restoring the river close to its natural state. The third alternative would retain most of the cultural values yet providing free passage to all fish and aquatic life. Environmental impact assessment was found not to be mandatory for the project as the objective is to improve the environment.

6.2.2 Latvia

In Latvia, one restoration demonstration project was included in the RETROUT project. The restoration project concerned the planning and building a fish passage in Rīva river around the remains of an old paper mill dam with an artificial waterfall. One design company was procured to produce detailed plans and design documents for the fish pass solution, and a construction company was procured for execution the building work according to the design. The fish pass solution was successfully completed although with some delays. Monitoring and assessment of the ecological effectivity and final project evaluation still are to be carried out. Challenges in the project included, e.g., land-ownership issues, project teamwork and transparency, and finding of compromise solutions and consensus between competing ecological and cultural-economic interests and involved stakeholders. Communication and cooperation between and among the project core team (Kurzeme planning region, Ventspils county municipality, and BIOR), designers, construction company, construction supervisor, and landowners and other key stakeholders, was established and continued, but the practise could have been more active and comprehensive. General lessons learned were that good cooperation and active supervision are needed in the relation between the project team and the designing company, all interest groups should be involved in all key stages of the planning process, a restoration project needs to be adaptable to new information that emerges, and importantly, all complications can be solved through transparent practices and active cooperation where all involved actors together focus on finding the overall best possible solutions.

Rīva river fish pass

Rīva river is about 53 km long and discharges to the Baltic Proper. Water quality is classified as good (only downstream reach of this river has been evaluated) and the river a has native sea trout population as well as Atlantic salmon, among many other migratory and resident species. The remains of old paper mill dam in Jūrkalnes parish are located 1.2 km from the sea and it is the most important obstacle in the river. This is the main migration obstacle for fish, although there is another barrier, a water level regulator of Vilgāles lake, which is located ~0.5 km from the source of Rīva river. The remains of old paper mill dam create a ~1.2 m high waterfall followed in upstream direction by a concrete wall with a narrow gap and concrete structure with a pipe. Total water level drop in this barrier is ~2.2 m and it is considered a migration obstacle for most fish. Approximately 98 % of the riverbed is located upstream this barrier. Particularly good potential spawning and rearing habitats for sea trout and other migratory fish are found in a 13 km long section upstream the barrier, whereby the full production capacity of the river for these species is severely restricted.

The dam belongs to the remains of an old unfinished paper mill. The dam has no active function as such, but the artificial waterfall created by the dam together with a wooden bridge constitute a popular sightseeing object and a tourist attraction with its adjacent café. The most effective solution ecologically would have been a complete removal of the dam. However, due to the cultural and economic interests related to the dam and strong stakeholder opinions in favour of preserving the dam, it was evident that removal was not possible and instead a fish pass was needed.

Based on the initial planning and the prerequisites for the project, a fish pass solution was developed and designed. One major challenge in the project was a landowner issue in relation to the Interreg Programme/ERDF rules, which, however, was successfully solved by a long-term land leasing contract for the area on the riverbank where the fish pass is to be built on. The first migration solution produced was a technical fish pass ensuring migration only over the lowest part of the barrier. After expert consultation, this was found not effective enough to provide migration opportunities also to fish species that are weaker swimmers, and the solution was hence considered insufficient in relation to the project aims. Thereby, the type of the fish pass was changed from a technical fish pass to a natural-like fish pass, and new designs were produced accordingly. The land-lease agreement was complemented as the natural-like fish pass required more land area. Finally, a 110 m long fish pass was installed. However, partly due to a faulty design and partly due to faulty construction work, the new fish pass had severe problems, inter alia in form of three new obstacles effectively obstructing fish migration, and as a non-functioning installation of 'migration pipes' in the channel. Also, there was extremely little water in the channel during low water conditions.

As an adaptive measure, needed corrections in the design of the fish pass were made and a reconstruction to address the identified problems was done. The new solution ensured better migration possibilities for all fish and simultaneously secured enough water for the main channel to retain the artificial waterfall as a tourism attraction. Thereafter in late 2020, the fish pass has been in operation. Further monitoring of the functionality of the fish pass in various conditions will be carried out during the coming seasons.

The total cost was about 220K €. Environmental impact assessment was not conducted as it was not applicable according to national regulations. To assess possible changes in sea trout (and salmon) production two upstream electrofishing monitoring sites were established in 2018. In addition, monitoring of lamprey larvae has started. Monitoring in these sites before and after completion of the fish pass will enable assessment of changes in sea trout and lamprey reproduction and can hence be used to evaluate the effect and success of restoration measure. Importantly, despite some difficulties the project finally showed adaptability in front of new, crucial information, and by working together a joint improved solution was found.

6.2.3 Lithuania

In Lithuania, two restoration demonstration projects in river Smeltalė were included in the RETROUT project. These concerned the planning and implementation of a biopond system recultivation for improving water quality and habitat improvement of sea trout spawning and nursery area. Both restoration measures were successfully completed and are now in use.

Bio-pond system and habitat improvement in river Smeltalė

The Smeltalė River flows into the Klaipėda Strait, which connects the Baltic sea and the Curonian Lagoon and has a catchment area of 124 km^2. The river has a self-sustaining production of original strain of sea trout, but the reproduction has decreased during the last years. Water quality is classified as poor due to eutrophication, perhaps being one cause for the low trout production. A biopond-system was established in 1996 to improve the water quality. It consists of several sedimentation ponds, anaerobic ponds, and aerobic ponds. Since then, it has not been managed properly and it was suspected that the nutrient reducing efficiency had decreased. In 2018 the pond was completely overgrown. A study of the efficiency was performed within the project. It was found that the reduction of the total phosphorous concentration was only 1–4 % as compared with the expected 10–15%.

Based on the initial planning and the prerequisites for the project a project to restore the non-working biopond system was designed. During the restoration 3300 m^3 of sediment was removed and much of the overgrowth was cleared. The area is now used for recreation and education. A follow-up study of the nutrient reduction has not yet been performed.

In the Smiltaitė tributary restoration measures were applied to a small stretch running through a small park. The land is privately owned but water in Lithuania is state owned, which facilitated the activities. All measures were applied in the water. Sea trout spawning and juvenile rearing habitats were created in the stretch. This was the first ever creation of spawning grounds in Lithuania and it proved to be a great success: 13 spawning reds were found in 60 m of restored habitat. Now, visitors of the park can see trout spawning in the middle of the park.

The restoration activities in Smeltalė river have already influenced restoration outside the project. The first ever dam removal in Lithuania has been carried through. This was a small dam that was not a migration obstacle, but the removal has a symbolic value by showing that dams can be removed in the country. The second ever dam removal is planned this coming summer in Salantas river. It will also be combined with habitat improvement activities. To conclude, the Smeltalė project has created greater knowledge among stakeholder groups about the importance of river restoration.

6.2.4 Poland

In Poland, one restoration demonstration project was included in the RETROUT project. This concerned expert observation and monitoring of the planning and preparatory stages of a restoration project concerning a fish pass solution to overcome a migration obstacle in the Reda river, with the view to improve river connectivity and through that increase biodiversity, and in particular, to recreate the historical spawning grounds of salmonids above the barrier. One company was procured by the project responsible authority for conducting the technical design documentation and an Environmental Impact Assessment. The project is funded and implemented outside RETROUT budget. Planning, designing and initial preparatory work has been conducted. All needed permits have been issued and are valid. To proceed with the project implementation, sufficient funding still needs to be secured. Additionally, monitoring and assessment of the ecological effectivity and final project evaluation still need to be planned and carried out. Except from budget issues, no major challenges in the project have so far been encountered. A general technical lesson learned so far is that solutions with natural-like characteristics is the preferable when restoring river connectivity if the obstacle cannot be removed.

Reda river fish pass

Reda river is about 50 km long and discharges to Puck Bay. Water quality according to the WFD is classified as good, and the river a has a sea trout and salmon population supported by stocking, as well as other migratory and resident fish species. The Ciechocino damming weir in the town Reda is located 9.4 km from the sea and it is the first of the two main migration obstacles in the river. The current hight of the barrier is 1.7 m and it is considered a migration obstacle for most fish. Reda river in lower section is regulated and canalised, but spawning and rearing habitats for sea trout and salmon are found upstream the barrier, whereby the full production capacity of the river for these species is currently restricted.

Due to the weir and a poor-functioning old fish pass, the hydrological continuity on the Reda river challenged. The damming weir has a valid water permit and has an active function for the purposes of rainbow trout farms, and therefore cannot be removed. Instead, a new fish pass solution was considered and developed. A positive outcome of the Environmental Impact Assessment was received, stating that the fish pass is expected to have a long-term positive impact on the environment by improving the biological continuity of the river. Further, all needed permits have been granted.

Based on the initial planning and the prerequisites for the project two alternative solutions were developed. The first alternative was the construction of a technical fish pass in the form of a vertical slot fish pass. The second alternative was the construction of a fish pass in the form of a ramp with natural-like features along the riverbank. The second alternative was preferred and chosen as it enables migration all aquatic organisms, fully meets the project objectives, and comes with similar cost estimates as the first alternative. The fish pass also includes accompanying infrastructure work such as a channel valve reconstruction, a wind power plant, and connection to the power grid and the relocation of power cables in the way of the fish pass. Plans exist also for installation of permanent continuous fish migration monitoring by fish scanners and cameras.

The needed stages of project have been planned and the project is currently at the beginning of the construction phase, awaiting final funding securement. The total cost of the project was about 1.1M €. National and international financing sources have been investigated, with the view of starting the construction phase in 2021. Once started the construction work is estimated to be finished within approximately 10 months. The effectiveness of the new fish pass will be confirmed by monitoring of ascending fish with a hydroacoustic monitoring system. So far, the project has proceeded successfully despite some delays. The final evaluation of the project's successfulness can be done only after completion and operation of the new fish pass.

6.2.5 Sweden

In Sweden, five restoration projects were carried out in the rivers Bränningeån, Erstaviksbäcken, Vitsån, Skeboån and Moraån. The restoration projects concerned planning and implementation of several smaller habitat restorations and two fish pass constructions. These restoration projects were included in the RETROUT project but were implemented with other funding. Depending on the restoration project different project teams, key actors, public authorities, and stakeholders were actively involved. Also, a designing company and construction entrepreneurs were procured and used in the different projects as needed. Of the five restoration projects four has been successfully finalised. The restoration project in river Skeboån, concerning the installation of a fish pass around a pulp factory dam, currently stands in a conflict situation with the pulp factory concerning water supply issues. General lessons learned have highlighted the importance of well-functioning stakeholder communication to seek consent and support, of careful planning and competent implementation, continuous supervision for ensuring correctness and high quality of measures, and the important role of informing and engaging the general public in restoration projects to gain understanding and support.

River Bränningeån habitat improvement

River Bränningeån is about 16 km long and discharges to the southern Stockholm archipelago. The ecological status of the river is classified as moderate and the river a has previously stocked but now reproducing sea trout population among resident species. The poor status is due to eutrophication and physical alterations (fish migration obstacles and morphological changes). Furthermore, the river has reduced habitat complexity due to the removal previous removal boulders and lacks a natural gravel bottoms in many places. Despite these reduced conditions, seatrout reproduce in the lower part of the river. However, due to the suboptimal living conditions, the production potential of the stretch is not fulfilled.

The dams close to Bränninge mansion at the lowest 1 km stretch of the river are definite migration obstacle for all fish. The dams have caused erosion and deepening of the watercourse downstream the dams. Flow variation is low with only a few riffles and runs. Due to high cultural heritage values, the dams cannot, however, be removed, although that would be ecologically the soundest measure. But instead, by returning gravel, boulders and large logs to the stream below the dams, heterogeneity in physical structure and flow would increase, which benefit biological diversity and the production of sea trout. Thereby, an improvement of the river habitat was initiated, with the aim to restore of the lower part of river towards more original-like conditions.

Based on the initial planning and the prerequisites for the project, a solution to restore and improve three spawning and rearing stretches, by adding gravel, stones, and logs, was developed and designed. The area surrounding Bränninge mansion has high historical value, which is important to preserve. After early stakeholder meetings with the landowner, it was clear that high historical value of the area needs to be preserved but permission was given to apply habitat restoration measures on the lower stretch. After preparations and procurement of a construction entrepreneur, the plans were implemented. A total of 280 tonnes of gravel and stone were added to the river over three stretches, to create spawning and nursery grounds for sea trout. Also, logs were placed in the channel to increase structural complexity and supply of woody debris. Two larger riffles were created, and existing deep pools were preserved. In conclusion, the measures created a greater variation in the river with better conditions for sea trout. The planned restoration work was successfully finished in 2019.

The total cost of the project was about 20K €. Environmental impact assessment or any permits were not required. Stakeholder communication and public outreach have been very successful throughout the project. To follow up the effect of the restoration, sea trout parr density monitoring was conducted prior to the work in 2018 and is continuing over the coming years. Regarding the hydro-morphological features of the restored section, much have improved but it is yet too early to assess long-term effects on sediment transport, meandering and other characteristics.

River Erstaviksbäcken fish pass renewal

River Erstaviksbäcken is about 5 km long and discharges to the southern Stockholm archipelago/Erstaviken. Water quality is classified as good and the river a has original, native sea trout population as well as river lampreys, among other resident species. An old non-functioning fish pass at Ersta manor are located 200 m from the sea and it is the lowest of three migration obstacles in the river. The old fish pass is placed downstream a culvert under a road and was originally constructed to allow fish to pass the culvert that created a waterfall. The current over all elevation the old fish pass/barrier is 1.5 m and it is considered a migration obstacle for most fish. The river further suffers from poor river morphology and lack of accessible spawning grounds in good condition. Upstream the migration obstacle some potentially good spawning grounds exists, whereby the full production capacity of the river for sea trout and other migratory species is severely restricted.

The long-term aim of the restoration activities in Erstaviksbäcken is to create conditions for a stable and growing sea trout population and increase biological diversity upstream the malfunctioning fish pass. A solution enabling free fish migration would also warrant and pave the way for more habitat restoration measures upstream the barrier. Removal or improvement of the old fish pass, tree planting in the riparian zone, and various habitat improving measures were identified as possible actions. The area around Ersta manor has high cultural heritage values and a park, frequently visited by the public. It became clear that replacing the technical fish pass with a natural-like channel was not an option due to the sensitive settings around the manor. Therefore, a solution to build a new, improved fish pass was accepted by all stakeholders, and it was thereby chosen. A more natural fish pass would have been preferred had there been no other interests to consider.

Based on the initial planning and the prerequisites for the project, a new fish pass built in wood with less slope for improved migration possibility was developed and designed. Following the design, the new fish pass was built, the old one removed and the new one then installed. Before the installation of the fish pass, spawning gravel and larger stones was be placed in upstream stretches to create spawning and nursery grounds. The work was done by with the aid of two local fishing clubs.

The total cost of the project was about *40K* €. Environmental impact assessment was not needed. Stakeholder communication and public outreach have been very successful throughout the project. It is too early to know whether the fish pass will have the wanted function or not, but the water flows through the pass as predicted. It is believed though that the resulting fish pass will have the wanted function. Sea trout and other migratory fish species are expected manage migration up the fish pass to their spawning areas. The first follow-up results are expected after electrofishing and roe pit counts during 2021. Likewise, the habitat improvement measures will be evaluated during 2021.

River Vitsån habitat improvement

River Vitsån is about 22 km long, including the tributary Rocklösaån, and discharges to the southern Stockholm archipelago. The ecological status is classified as moderate and the river a has mixture of wild and stocked sea trout as well as other migratory and resident species. The river is heavily affected by human activities such as straightening, removal of stones and logs, culverting, construction of impoundments and other structures preventing fish migration, land fill and drainage, and the use of the riparian zones for agriculture, settlements and roads. Consequently, suitable habitats for spawning and young sea trout are found in only 10 % of the river. Despite the in general poor environment, seatrout is reproducing in several stretches in the river, and the potential for increased production and biological diversity is large, provided that efficient restoration measures are applied.

To improve the conditions extensive measures in the whole river are needed. This restoration projects targeted two areas. The first site at Vitså mill is located close to the river mouth, and the second site is in the tributary Rocklösaån flowing through a park in the town Tungelsta 10 km from the sea. The first site has high historical value due to the mill remnants, while the second site is one of the few urban area suitable for restoration measures. The aim of the projects was to improve the river environment for sea trout and other aquatic organisms and to create a more heterogenous habitat with spawning and nursery sites for sea trout. In Tungelsta, the restoration project was also linked to the municipality's aim of making nature more accessible to the visitors of the park.

Based on the initial planning and the prerequisites for the project, solutions to create a natural-like river floor similar to the pre-dam state (Vitså mill) and to create spawning and nursery areas by adding gravel, stones, and logs (both sites), were developed and designed. After securing all needed permissions and stakeholder approval, concrete implementation was started following the plans. At the Vitså mill site, stones of different sizes were deployed in the river on a 120 m long stretch upstream of the former mill dam construction. Some deeper parts were left unaltered. Several larger logs were placed in the watercourse. Additionally, young alder trees were planted along the riverbank to increase shade. In Tungelsta park, a total of 50 tonnes of stones and gravel were distributed in about eight different locations of the river, to create riffles and sea trout spawning sites. The restoration measures were successfully completed in 2018 (Vitså mill) and 2019 (Tungelsta park).

The total cost of the project was about 15K €. Environmental impact assessment was not needed. A sea trout parr monitoring established at Vitså mill site before and continued after the restoration showed that 0+ parr density increased whereas the number of older fish decreased, indicating that the measures have benefitted sea trout production although older parr have moved to other stretches more suitable for them. At Tungelsta park, follow-up electrofishing will be carried out in 2021. There are however already proof of trout spawning in the restored stretch in form of observed spawning pits. Furthermore, the habitat improvement efforts at Tungelsta park have also been used for educational purposes for school classes through "Sea trout day".

River Skeboån habitat improvement and fish pass

Skeboån is situated in Norrtälje municipality 100 km north of Stockholm. The river basin is 480 km^2 and is dominated of forests with about 10 % agricultural land and just below 2 % of urban areas. The river flows from Lake Vällen near the border to Uppsala County and empties into Edeboviken by Hallstavik. The water quality is better in the upper parts of the river, with the lower parts having unsatisfactory ecological status according to the Water Framework Directive. The major environmental problems are eutrophication, migration obstacles and physical impact – clearing of stones and logs, straightening of the river, removal of controlling sections. However, the river has good potential as a sea trout habitat and is recognised by HELCOM as one of the Baltic Sea watercourses that need to be restored to increase the production of sea trout in the Baltic Sea. The great potential is not realized today in part due to several dams that constitute migration obstacles for sea trout and other fish. At the river mouth there is a dam with a fish ladder with limited passability. Ten kilometres upstream, in Skebobruk old ironworks, there is another dam which is a definite migration obstacle for all fish. There are sea trout between these migration obstacles, but the population is according to electrofishing results weak. The sea trout population is a mixture between stocked and wild trout. The reason for the weak population is not known, but general poor habitat quality is belied to be important. Some habitat improvement measures have been implemented earlier with good results, but the work needs to continue. The project intends to design and build a fish pass at the dam at the mouth to increase the possibility for fish to pass and to work with habitat improvement measures between lake Närdingen and the river mouth. Responsible for the activities have been The County Administrative Board in Stockholm and The Swedish Angling Society.

At two sites, Skebobruk 10 km from the river mouth and Häverödal, 3 km from the sea, habitat improvement measures were implemented by adding large stones and gravel to the riverbed. The purpose was to create spawning grounds and holding spots for older trout. Cultural heritage experts and landowners have been involved in the process and a local fishing club have participated in the implementation of the activities. Follow-up electrofishing and redd counts are planned for the year after the activities and the following years. However, already 32 spawning sea trout have been observed at the Häverödal site.

The fish pass past the dam close to the river mouth is a complicated issue. The dam is needed to provide a paper pulp mill with water for the paper pulp process. The owner is positive to a fish pass provided that it does not jeopardise the paper production in any way. There were concerns that the available volume of water would not cover the requirements for both a fish pass and the factory. In addition, there is a water works that provides the community with drinking water that also uses river water. To solve this issue, a hydrological model was developed and by using this, different water regulating regimes could be simulated. It was concluded that with a more efficient automatic regulation of the dams in the river basin, the available water would be enough for all purposes. Several fish pass designs have been proposed, but none has fulfilled all biological and process engineering requirements. It has also become apparent the dam is leaking water even when closed, reducing the effect of any measures to make the water use more efficient. Next steps will be taken during spring 2021 and will include development of a new fish pass design with cost estimation and method and cost estimation of sealing the leaking dam. The plan is to start construction during fall 2021.

River Moraån: habitat improvement

River Moraån in Södertälje municipality in Stockholm County has two main tributaries, one called Kallforsån is about 20 km long and the other, Ogaån is 15 km from source to the junction with Kallforsån. The two branches join 6 km from the discharge in the southern Stockholm archipelago. Water quality is classified as moderate according to the Water Framework Directive and the river a has native, unique sea trout population as well as eight other species, including river lampreys. The main environmental issue in Moraån is a poorly functioning fish pass in Järna 5.5 km from the river mouth. It is a complete migration obstacle for all fish but strong sea trout. There is some reproduction upstream the dam, but it is very poor compared to downstream, were regularly 100–150 young trout per 100 m^2 are found during electrofishing. There is an ongoing process to build a fish pass past the dam, but it is outside of this project. A river habitat survey showed that river morphology has been changed in large parts of the river by clearing of logs and stones, reducing the area of suitable trout habitats.

To restore parts of the river and compensate for the large physical changes new spawning grounds and holding spots were created at two sites in the river; one in Kallforsån 20 km upstream the river mouth, and one 1.5 km from the coast. Once the migration obstacle in Järna is removed, this site will be available for all migrating fish. So far, only resident of strong trout can reach this spawning ground.

The activities at the Kallforsån site were implemented by the Swedish Angling Society in cooperation with The County Administrative Board of Stockholm. Close contacts were held with Södertälje municipality. Landowners and other stakeholders were informed. Due to a misunderstanding in the communication between the Angling Society and the municipality, an exemption from the beach protection act was never filed. It had to be filed after the project was completed and was then accepted. This was an important lesson learned. Whenever unsure if a permit is needed or if no written exemption is given, an application to the competent authority should be filed according to the precautionary principle. Another lesson learned was that early stakeholder involvement is key to success and can help avoiding misunderstandings. Part of the public reacted negatively when they saw excavators in the river. There was an information sign explain the reason for the activities and responsible organisations. However, this was apparently not enough. A meeting where the general public was invited and informed about the activities could have avoided the negative reactions.

The activities at the site close to the coast was implemented by Södertälje municipality together with the County Administrative Board. A more natural river stretch was created from a heavily cleared stretch by adding stones and gravel to the riverbed.

No electrofishing has been done yet at any of the sites, but monitoring is planned to be performed during 2021. Both sites have now an increased diversity of structures and niches, and prospects are good that trout spawning will increase.

7 Synthesis of best practices and recommendations for river restoration projects in the Baltic Sea Region

This chapter consist of a synthesis based on previous chapters (Chapters 4–6). Key take-home messages and lessons learned have especially been obtained from the study on river restoration success factors (Chapter 5) and the river restoration demonstration cases (Chapter 6). Through these input sources both first-hand information of experiences from a variety of concrete restoration projects and detailed analytical information from a considerable number of different types of past restoration cases have been gained. The material covers most of the Baltic Sea coastal countries and a broad selection of different types of restoration projects, providing a diverse overview on practices in river restoration projects. The key messages and lessons learned that were fed into the best practices, related to matters like ecological knowledge and problem identification, important societal and project specific conditions affecting restorations, project team, stakeholder management, choice and prioritisation of restoration solution and measure, monitoring and project evaluation, for instance.

The gained knowledge and experience regarding river restoration projects are synthesised to a set best practices and recommendations. For the purpose of this report, 'best practices' have been defined as a procedure or proposed standard composed of conditions and actions leading to optimal results, following with modification the definition of 'best environmental practices' given in the Helsinki Convention Annex II: "*The term "Best Environmental Practice" is taken to mean the application of the most appropriate combination of measures*"[10]

These best practices give a thorough successive overview of the generic river restoration project, describing important settings and actions for all stages and highlighting key aspects that promote successfulness of the project. This comprehensive project process description is concretised by practical examples, technical details or other specific information particularly concerning Baltic Sea region sea trout river restorations in this context. Based on the best practices, the key messages are extracted and presented as recommendations for river restoration projects in the Baltic Sea region. The best practices and recommendations can be used by river restoration practitioners as well as local, regional, and national public authorities of concern. Additionally, this can serve the macro-regional level by providing input for policy recommendations at HELCOM and EU levels.

7.1 Best practices for successful river restoration projects

Based on the chosen rationale and available input material used, best practices for successful river restorations in the Baltic Sea region were developed. The best practices are organised and presented following a generic procedure for restoration projects with five indispensable interconnected phases that must be effectively undertaken to achieve the expected outcome (Figure 3; Holl and Cairns, 1996). For each of the project phases (1–5) first the basic features of the phase are described followed by the descriptions of the synthesised key elements and best practices. The identified best practices comprise two elements: *optimum conditions* and *necessary actions*. The *optimum conditions* describe the most conducive background situations for achieving a favorable outcome in the concerned project phase, while the *necessary actions* describe the processes that must be adopted for completing the concerned project phase. In other words, the first dimension of the best practices tells what is needed or what should be in place as a prerequisite or a factor of facilitation

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[10] In the Helsinki Convention the term 'Best Environmental Practice' originally relates to prevention and elimination of pollution of the Baltic Sea Area (The Helsinki Convention of 1992, Article 3 §3).

to carry out a successful restoration project, and while the second one denotes what needs to be done or the necessary steps and tasks for advancing in the project. The best practices are visualised in Figure 3, summarising the identified key conditions and actions throughout a river restoration project.

Phase 1: Initiation

Optimum conditions

- Strong/clear incentive
- Suitable target river
- Sufficient background information
- A primary interest group

Necessary actions

- Surveys for background information (if not available)
- Problem identification
- Formulation of the project intent
- Early identification and involvement of interest groups

Phase 2: Preliminary survey

Optimum conditions

- Clear project intent
- Supporting policies and legal frameworks
- Enabling water- and landowners
- Involved and engaged interest groups
- Comprehensive background survey reports

Necessary actions

- Assessing and securing resource availability
- Analyses of stakeholder interests
- Selection of best solution and restoration measure

Phase 3: Project planning

Optimum conditions

- Comprehensive background survey reports
- Selected solution and best restoration measure
- Supporting policies and legal frameworks
- Harmony of interests and stakeholder consent

Necessary actions

- Sound planning and technical design
- Long-term financial planning
- Human resource planning for upcoming project phases
- Impact assessments and permission procedures
- Resolution of conflicts of interests (if any)
- Preparation of implementation phase
- Planning of project monitoring and evaluation

Phase 4: Implementation

Optimum conditions

- Good plan of action
- Effective technical design
- Secured permits, competence, workforce, materials and equipment for practical work

Necessary actions

- Implementation of the restoration measure

Phase 5: Post-implementation

Optimum conditions

- Effective plan for monitoring and evaluation

Necessary actions

- Operation and maintenance of interventions
- Continuous monitoring and evaluation of the project
- Communication of project results
- Adaptive management

Continuous elements

Optimum conditions

- Supporting/beneficial political and societal context
- Sufficiency of resources (financial and human)
- Cohesive and dedicated project team

Necessary actions

- Decision-making
- Stakeholder management and engagement
- Project communication

Figure 3. Generic process of a river restoration with identified key elements of best practices. Modified from Holl and Cairns, 1996.

7.1.1 Phase 1: Initiation

To initiate a restoration process, first and foremost an incentive is required. Then the initiation phase involves acquiring of relevant background information on the river, including ecology, hydro-morphology and water-quality as well as human interests, activities and pressures affecting the river. Against this background, the problem and its reasons need to be identified and specified. And finally, the desired future state or a reference system needs to be envisioned.

Optimum conditions

Strong and clear incentive: A successful restoration project needs a strong enough incentive to initiate the process of a river restoration. The incentive (i.e., the motivation or ultimate driving force) for river restorations can be related broadly to policies, social/cultural interests, or economic interests. Cohesive policies and regulatory frameworks, such as the EU WFD or the BSAP, provide strong encouragement or even binding obligations to act for ensuring that rivers attain good ecological status. National legislation might obligate compensatory actions for permitted operators utilising the river, for instance making the provision of a fish migration solution compulsory for dam owners. Also, current political priorities and corresponding funding reservations might promote active seeking of suitable restoration objects to fulfil the political agenda and to utilize the available funds. Incentive can also come from a strong enough social/cultural interest in nature protection and conservation, with the desire to strengthen valuable and/or endangered anadromous fish populations, or more broadly river health and biodiversity. In some cases, incentive comes from interests in a recreational value, for instance through lost or degraded angling opportunities. Economic incentive can appear when some economic activity ultimately dependent on non-degraded river (eco)systems, for instance fishing tourism industry, suffer or are limited.

Interest group: Related to the incentive needed, an initiation of a river restoration project requires a primary interest group. An interest group refers to a collection of individuals who share a specific common interest related to restoration of ecology of a river or the like. This group could be a public agency driving the process by assignment, or a non-governmental organization (NGO) concerned with nature protection, or an informal group of persons that are interested in improving the local ecological situation, or any other interested individuals. When the project is initiated, the primary interest group may form the project team to drive the process further, but this is necessarily not always the case. The primary interest group might also initiate the process and instead of leading it, act as a supervisory body, as funder, enabler (e.g., landowner), etc. If not a part of the implementing agency, the primary interest group that has initiated a project would constitute an important stakeholder for the project.

Suitable target river: Given that there is incentive to initiate the restoration process, next the ecological context is the most important background factor defining a river restoration project. First, this involves the choice of the target river. The choice can be implicit or active, depending on the initial circumstances. If the restoration incentive directly relates to a specific river the focus and starting point is clear. But when a restoration process originates from need to fulfil political goals or requirements of a funding programme, the initial choice of a target river needs to be taken. When available resources usually are limited and the broad-scale objectives pre-specified (e.g., restorations to improve sea trout populations), suitable rivers in need of restoration need to be selected carefully based on informed criteria (e.g., the river has unrealised potential for high sea trout production capacity) and prioritised to achieve optimal impact for the foreseeably available resources. The matter of selecting a target site or location can sometimes be self-evident already at this stage (e.g., a dam preventing all migration), but optimally this is another process taking place after the background settings are assessed (see section below), in the second project phase when the solutions for the existing problem(s) are chosen, including where and what to restore. Furthermore, sometimes an informed choice of the target river requires knowledge in form of background information of the river characteristics and condition, which may or may not exist in advance, and, thus, the choice of target river and the need for background information might not always be entirely separate matters. General criteria for a suitable Baltic Sea sea trout river for restoration are briefly listed in Box 3.

<u>Background information</u>: When the target river is known, a successful restoration project requires good background information for understanding of the condition of the river, its structure and function, to identify pressures and causes for sub-optimal conditions, and for acknowledging demands for ecosystems services from the river. Here again the ecological context is the most important background factor defining a river restoration project. Holistic knowledge of the river ecology and pressures affecting the river and fish populations at specific locations and on a whole-river scale is needed. This includes, inter alia, knowledge about the river drainage area, large-scale hydro-morphological qualities, quality of specific river habitats, water quality and quantity issues, river connectivity (by identification of all migration obstacles), status of river biota (e.g., origin and status of sea trout population), any other related ecological settings as well as problems in the river and river basin that can affect the target fish populations. Optimally also cultural/historical and recreational values, and other stakeholder interests are recognised already at this early stage. The needed background information, or parts of it, may pre-exist through regular monitoring for river status, or if not, then surveys to obtain this information need to be performed.

Necessary actions

<u>Surveys for background information</u>: To start off successfully, a restoration process must be preceded by necessary surveys of the current condition and settings if such knowledge does not initially exist (see above). Comprehensive background surveys can include hydrological, environmental, social/cultural or other aspect relevant for obtaining an adequate understanding of the state of the river. Important aspects included in a background survey for a sea trout river in the Baltic Sea are listed in Box 4. To conduct a background survey, sufficient resources in terms of competence, manpower, funds and time need to be secured. In practice, a public or private agency or some other competent expert organisation usually will be responsible for planning and undertaking the needed surveys.

<u>Problem identification and formulation of intent</u>: Against the background information, the problem(s) and its reasons can and need to be identified and specified. To have a clear problem context is a prerequisite for starting a focused yet comprehensive enough restoration project to address it. Then, the desired future state or a reference system needs to be envisioned. Given the problem in hand and the future state to strive for, the basic project intent is formulated, and the restoration project is initiated.

On Baltic Sea region wide general level, intents for salmonid rivers in poor shape have been formulated in the HELCOM Recommendation 32-33/1, stating that passage through the rivers should be provided when justified and that action should be taken for the restoration of river waters and habitats towards a salmonid habitat in good state as defined in the Recommendation (Box 5).

Identification of interest groups: Early identification and involvement of interest groups is important and promote success of river restoration projects. Some or all of the interest groups might become stakeholders in the initiated project and establishing good relations early can prove beneficial throughout the project.

Box 3. Criteria for selection of suitable sea trout rivers for restoration in the Baltic Sea region.

Broad-scale criteria for prioritisation of Baltic Sea sea trout rivers for recovery measures have been defined by HELCOM (HELCOM 2011; HELCOM RECOMMENDATION 32-33/1) and include low production levels and an originality of the river's sea trout population. Originality of the population refers to a genetically original strain not affected by introductions or releases of other strains. Low production can be defined as production level less than 50% of the estimated potential production capacity of the river. Thereby, a river with an original sea trout population reproducing at a low level would be classified as a high-priority river for recovery measures. Based on these criteria a list of priority sea trout rivers has been developed. This original priority list contained 299 Baltic Sea sea trout rivers (Annex III in HELCOM 2011).

Below listed general and specific criteria for selection suitable sea trout rivers to be restored.

General

- A current (or historical) sea trout population
- A sea trout population of specific conservation value (e.g., a self-sustainable original strain)
- High potential for increased trout production (primary objectives)
- High potential for increased biodiversity (secondary objective)
- Man-made changes have caused environmental deterioration

Specific

- Slope at least 1 m/km, but preferably 2 m/km or more
- Width not more than 15 m but preferably 6 m or less
- Average depth in low flow conditions less than 0.5 m preferably less than 0.3 m
- The stream must retain enough base flow in dry periods to sustain aquatic fauna (in short-term trout parr can survive in ponds)
- Water quality, or potential for it, must be good enough to sustain aquatic fauna (water quality issues can be addressed by restoration)
- The stream has good connectivity and routes to/from the sea or clear potential for it (connectivity issues can be addressed by restoration)

Additional (*)

- Expected impact of restoration is high relative to expected cost
- Interest groups positive to a restoration
- No prohibiting legal conditions
- Manageable cultural heritage values
- Foreseen feasibility of finding a well-functioning restoration solution to an identified problem

* these aspects might also be clarified later in the project process, or they are aspects that might not be crucial for the possibility of a sea trout river restoration

Box 4. Important aspects included in a background survey for a sea trout river in the Baltic Sea.

- Information about the target sea trout population (origin, uniqueness, time series of population indicator)
- Biological qualities (biodiversity inventories of fish, benthic fauna, macrophyte flora, diatom community)
- Water quality (nutrients, hazardous compounds, and pH as well as biological parameters that can be used as indicator of water quality)
- Hydro-morphological qualities (a river habitat survey increases understanding of the present status of the river)
- Physico-chemical qualities (temperature and oxygen regulation)
- River connectivity (migration obstacles)
- Cultural heritage values (historical events that has shaped the site, which objects that needs protection, which that may be removed or altered)
- Social aspects
- Main interest groups using the river
- Main pressures affecting the river (e.g., dams and other obstacles, eutrophication, transport of fine sediments, etc.)
- Other aspects relevant for obtaining an adequate understanding of the state of the river to identify the existing problem(s)

Box 5. A set of criteria for a salmonid habitat in good state, as defined by HELCOM Recommendation 32-33/1.

- The river has a natural meandering that provides for diversity of habitats.
- The quantity and velocity of waters are sufficient, and the flow is maintained at an adequate level corresponding to the needs of salmon and sea trout eggs as well as young and adult fish.
- The water is cool and well oxygenated and stays within a limited pH range.
- There are spawning and nursery areas with the necessary bottom substrates (permeable gravel, cobble and sand).
- There are both deep pools and large boulders and stones as well as large woody debris suitable as hiding and resting sites for salmonids.
- The load of nutrients, organic substances, sediments and sand from the riverbanks is low and littering or contaminants do not affect the waters or bottoms.
- Vegetation along the river provides for shade and predator protection for fish as well as habitats for insects that may disperse over the waters as suitable food items for salmonids.
- The growth of vegetation in the rivers is not excessive.

7.1.2 Phase 2: Preliminary survey

In Phase 2 of a restoration process a preliminary survey is conducted to establish priorities, objectives, and strategy. Potential solutions and alternative measures are acknowledged. Likewise, the possibilities and restrictions in terms of resources and time, policies and legal frameworks in force, as well as foreseeable potential difficulties and challenges in carrying through the project, need to be known. The rationale, justification, and feasibility of different alternative solutions are evaluated and compared. Given the context of needs, possibilities, restriction and expected effectiveness, the preferred solution or solutions are chosen for the project to be further developed.

Optimum conditions

Clear project intent: To start the preliminary survey for finding out a suitable solution and restoration measure, first a clear project intent is needed. One need to know what the project wants to do and for what purpose (for instance *restore fish migration to get stronger self-sustaining populations*). The intent should have been formulated already in the initiation phase based on the problem identified and the desired future state envisioned.

Supporting policies and legal frameworks: Policies and legal frameworks in force can strongly steer river restoration projects through facilitation or restriction. Policy context can thus play a major role in determining the sustainability and success of a river restoration project already from the start. Regional or international policies and regulatory frameworks, such as the EU WFD or the BSAP, can help by providing a common set of principles and practices to follow. This is important especially regarding restoration projects in transboundary rivers. National regulations and legislation or local policy frameworks might facilitate the success of a river restoration project through legal requirements for stakeholders carrying out activities that cause pressure to the river and its ecology. On the contrary, e.g., absence of legal provisions that can enable the transfer of private land and water for public good might prevent implementation of a restoration project. If conflicting legislation exists in favour of other than restoration interests, the possibilities for a restoration project might be restricted. Also, active political support starting early in the process can benefit restoration projects through steady institutional support and acceptance, better coordination with different stakeholders, and more stable financial resources.

<u>Enabling water- and landowners</u>: Ownership issues of river water and adjacent land can vary greatly between countries due to differences in legislations, and these issues can play a decisive role in planning and implementation of a restoration intervention. State ownership of rivers and adjacent land can often be a beneficial setting for restoration projects, given that the restoration is either initiated and implemented by the State agencies directly or that State interests and priorities support restoration activities. In other cases, if the ownership over these resources at the restoration site does not lie with the implementing agency, then the water- and/or landowners become key stakeholders in the project. Clear communication must be established with them and their consent in designing and executing the restoration must be secured at the outset. Depending on the legal provisions and the practical needs, transfer of ownership rights may also be sometimes required to enable restoration projects. It is important to address and fulfil this essential pre-condition, otherwise the result may be failure of the project.

<u>Involved and engaged interest groups</u>: Interest groups should have been identified and involved at the initiation phase already at the very start of a restoration project. Key interest groups will become stakeholders in the restoration project whereby early involvement and engagement is beneficial and will facilitate good relations throughout the project. Projects where stakeholders and their interests around the proposed project are included from the beginning often perform well. Especially important is early consensus, cooperation and a relationship based on trust and mutual support, all enabled by active and open involvement and engagement. Also, it is not uncommon for restoration ventures to receive practical support from various interest groups. For instance, fishing clubs or commercial fishermen associations often contribute with extra labour or resources.

<u>Comprehensive background survey reports</u>: The produced background survey reports serve as support throughout the pre-implementation phases for formulating, evaluating and selecting solutions and as well as for detailed planning. Comprehensive background survey reports can include information on hydrological, environmental, social/cultural or other aspects relevant for obtaining an adequate understanding of the general state and specific features of the river.

Necessary actions

<u>Assessing and securing resource availability</u>: Resource availability to support the restoration project is a defining factor for what sort of restoration can be done. Therefore, resource availability needs to be assessed and secured as an important part of the preliminary survey evaluating and choosing between different alternative solutions in relation to possibilities. Sometimes, when a restoration solution is very clear from the start the financial and other resource needs might first be estimated, whereafter the required funds are explicitly applied for or in another way secured based on the estimation. In either way, adequate funds on a long-term basis are essential for project sustainability and success of any river restoration project and need to be secured before the project can start. Funds are needed throughout the project, e.g., for project staff costs, administration and permission procedures, hiring of consultant expertise for planning and design of restoration measure, for material cost and practical restoration work, monitoring and project evaluation work, maintenance

needs, and project communication. In addition to adequacy of funds, knowledge and skills can also be seen as centrally important required resources of a restoration project. To achieve a successful restoration project, relevant knowledge and skills are needed for instance for project management (including finances and budget), legal and regulatory aspects, and communication, in addition to the essentially required expertise in river restoration measures, including understanding of river hydro-morphology, biology/ecology, and sometimes engineering. The availability of the necessary human resources in this regard must be surveyed alongside the financial resources, and an assessment of the stages and forms of their engagement be made.

Stakeholder analysis and identification of diverse interests: A project's success is said to depend as much on its stakeholders as on a good plan. In comparison to an interest group where the members merely share a specific common interest, project stakeholders are those individuals, groups and organisations whose interests may be affected as a result of a project decision or its execution or completion. Stakeholders thus need to be considered in achieving project goals, and their participation and support are crucial to its success. Consequently, stakeholder identification and analysis are important activities to ensure project success. It is important to assess conflicting or diverse interests in an early stage of the restoration process, and to act appropriately to resolve them and making an effective plan. Different stakeholder interests such as, cultural heritage, energy production, recreational value, etc. should be identified and possible conflicts with them described. This requires continuous, active and open communication with the stakeholders. An early involvement and engagement of stakeholders in the project helps to gain their confidence and participation. Diverse stakeholder interests need to be taken into account as a centrally important factor when evaluating and choosing the best solution for the restoration need (see above section). Elements and procedure of a stakeholder analysis is given in Box 6.

Box 6. Elements and procedure of a stakeholder analysis.

Stakeholders and their types

- All individuals, groups and organisations whose interests may be affected as a result of the project execution or completion must be identified and listed as the project's stakeholders.
- These may be classified into different categories. A useful scheme is to classify them into: a) Primary stakeholders: those ultimately most affected, either positively or negatively by the project; b) Secondary stakeholders: those indirectly affected by the project; and c) Tertiary stakeholders: those who will be impacted the least. Also, 'key stakeholders' that are most important or may exercise significant influence on the project processes and outcomes, may be distinguished.

Stakeholder analysis

- Stakeholder analysis is a way for the project team to learn the perspectives of stakeholders, their affiliation and areas they represent, what interests and/or perspectives they bring in relation to the project, any potential risks or adverse effects they might bring to the project.
- The stakeholders and their traits and interests may be usefully mapped using the following criteria: *Power* (high, medium, low); *Influence* (high or low); *Interest/Need* (high, medium, low); and *Support/Attitude* (positive, neutral, negative).
- Based on such mapping, relevant communication plans or mechanisms/schemes for their prioritisation and engagement may be designed. For example, those with a high level of influence and/or interest may be prioritised to engage with at the outset of the planning/implementation process.

<u>Selection of best solution and restoration measure</u>: Selection of the best possible solution and restoration measure to be taken is naturally a core issue and important for a successful restoration project. To acknowledge different potential solutions and alternative measures is a first important step in selecting the optimal measure for the river location and the identified problem. These alternatives then need to be related to available resources, restrictions and conflicting interests, and the different possibilities must be evaluated. The selection of restoration target location or site also centrally belong to the process of choosing the optimal solution. Sometimes the choice of target site might be implicitly clear from the beginning (e.g., a site of a migration obstacle), while it in other cases need to be carefully chosen to have the optimum impact (e.g., restoration of spawning habitats). A river habitat survey can indicate sites where the river has been straightened, cleared from stones and logs, where controlling structures have been removed or where other man-made structures affect the river habitat negatively. In practice, the best measure to be taken should be chosen based on its expected utility for the ecological objective relative to its costs, within the possibilities set by resources and limitations. Several inventories where river restoration measures are assessed from a cost and benefit perspective exist and can be consulted, taking into consideration also other conflicting stakeholder interests (see chapter 2). The selection of the most appropriate restoration measure should accordingly be made carefully following a thorough assessment of the various context-based factors described above. The fluency of the selection

process can be greatly facilitated by early and active inclusion of stakeholders achieving their consensus and acceptance (see below).

Removal of man-made migration obstacles is almost always a top priority in any watercourse. Exceptions exist, e.g., if there are unique sedentary trout populations or other threatened species that would suffer from open migration routes upstream the migration obstacle. Also, if there are natural migration obstacles or if the migration obstacle is built on a natural obstacle a “restoration” would actually create an unnatural situation and should therefore be avoided. If open migration routes are concluded to be the best solution, a complete removal of the obstacles should always be preferred. The reason is that a dam does not only prevent migration of fish and other organisms, but also efficiently trap sediment and organic matter in the dam. Furthermore, the natural hydrological processes that shape the morphology in a free-flowing river are heavily changed. The water loses much of its energy, that during natural conditions is used to transport sediment, stones and boulders. For these reasons dams and weirs result in drastic changes in morphology, and often reduced biodiversity. Therefore, the top priority for solving migration problems in any watercourse should be to remove the migration obstacle. If this proves impossible when all options are exhausted, a fish pass could be considered. For a fish pass, a natural bypass of the obstacle should be preferred. The advantage with a natural bypass compared to a technical fish pass is that the natural solution resembles a river with a possibility for spawning sites, nursery areas and holding spots, as well as other biodiversity. A technical fish pass will only provide an open migration route.

When considering which habitat restoration method to use, it is important to distinguish between different types of restoration measures. *Rehabilitation* is when the river processes are restored so that its morphology can revert to a natural condition. A good example is when the base level is restored by constructing an artificial controlling section, often called grade control structure. Classic *restoration* is when the rivers shape is reconstructed by use of machine power, e.g., meandering or creating a flood plain. *Habitat improvement* is when structures are added to improve habitat or prerequisites for a certain species or group of species. This is a very common type of restoration in trout rivers. However, the advantage of rehabilitation is that the river will reconstruct itself to a dynamic equilibrium, which is more stable than the other types of restoration and should therefore be preferred in most cases. If fast results are preferred, the other two methods could be used, but there is a risk that the river's natural processes, such as erosion, sedimentation and meander creation, will nullify the results in a few years. Concretely, many streams flow in artificial channels that have lost most of their original bottom structures and substrates. In such cases, either one of the two or a combination of both restoration by reconstruction of river shape and habitat improvement can be practised. This can, for instance, be done to reinstating gravel mats as a solution for a lack of suitable spawning areas, which is the among the most common restoration measures for highly affected sea trout rivers. A general selection procedure for the most common restorations in Baltic Sea sea trout rivers is provided in Box 7.

Box 7. A general selection procedure for the most common restoration activities in Baltic Sea sea trout rivers.

Identification of and descriptions and recommendations for the main recovery measures for Baltic Sea sea trout populations have been provided by HELCOM. These include restoration of river water and habitats towards a '*salmonid habitat in good state*', providing free passage in rivers were assessed feasible, and development and application of effective river fisheries management (HELCOM 2011; HELCOM RECOMMENDATION 32-33/1). Of these, river water and habitat restoration and free river passage provisioning are among the main restoration actions, while river fisheries management can be an important supportive action in the context.

Migration obstacle

1. Complete removal of the migration obstacle and restoration of the river to the state before the object was constructed (*)
2. Partial removal of the migration obstacle (*)
3. Nature like fish pass, a bypass allowing spawning ad biological diversity in the fish pass
4. Technical fish pass (**)
5. Temporary solutions like fish lifts, 'trap and transport', fish cannon, etc. (***)

Habitat restoration

1. <u>Rehabilitation</u>: Restoration of a rivers processes so that its morphology can revert to a natural condition. Example: restored base level by constructing an artificial controlling section (Grade Control Structure)
2. <u>Restoration</u>**:** Restoration of a rivers shape and processes according to its original condition
3. <u>Habitat improvement</u>**:** Adding structures to improve habitat or prerequisites for a certain species or group of species

*this also has a secondary habitat improvement effect as potential upstream spawning and rearing habitats currently flooded by reservoir are restored

**such fish passes are often well suitable for sea trout but might be problematic for other anadromous species like river lamprey

***such solutions should be primarily avoided

7.1.3 Phase 3: Project planning

The third phase in a restoration process encompasses planning and preparation of the project. This involves detailed planning and design of the chosen solution and restoration measure(s). Further preparatory work contains mandatory permission procedures. Also, any potential conflicts of interests with stakeholders need to be solved at this stage. Finally, the implementation phase needs to be prepared timewise and by securing required workforce. Alongside, the planning and preparations of the implementation of the restoration measure, also planning of project evaluation needs to be done.

Optimum conditions

<u>Selected solution and corresponding best restoration measure</u>: Based on the preliminary survey (phase 2) and the subsequent selection process for the best possible solution and restoration

measure to be taken, a chosen solution exists as the basis for the planning phase. From this solution and restoration measure, further detailed planning is then carried out.

Comprehensive background survey reports: The produced background survey reports serve as support throughout the pre-implementation phases for formulating, evaluating and selecting solutions and as well as for detailed planning. Comprehensive background survey reports can include information on hydrological, environmental, social/cultural or other aspects relevant for obtaining an adequate understanding of the general state and specific features of the river.

Support from political actors and public authorities: An important precondition for good project planning is continuous support and cooperation from political actors and public authorities at one or more relevant scales. This is important because legal, administrative, and financial settings affecting the process can all be defined by this, and, accordingly, needed support can be drawn or any existing barriers addressed. Also, the public authorities and political actors involved constitute an important part of the project's stakeholder group. Importantly, good integration and coordination between concerned authorities and actors at the different political scales – such as municipal and county or ministries of national governments – is central for successful restoration projects. In the case of transboundary projects, good bi- or multilateral coordination and cooperation of national agencies at relevant scales are important pre-conditions for project success.

Harmony of interests and stakeholder consent: Harmony of interests can have an essential effect on the possibilities to carry out a successful restoration. The location of a proposed river restoration project may be closely in conflict with the economic, cultural, historical, recreational, environmental or other values upheld by the local stakeholders regarding that site. If the planned location has minimum possible conflicts of interests, the project will ordinarily not face any opposition, which promotes a successful project outcome. If a project faces overwhelming conflicts that cannot be solved, a project might not be realised at all. Remaining conflicts of interests affect the planning phase of the restoration process and thus ultimately the potential for project success.

Necessary actions

Sound planning and technical design: Good detail planning and technical/practical designing is important for a successful restoration project. When the most appropriate restoration measure has been selected, there is need to ensure that the design is effective in operation. A design needs to meet the set restoration objectives yet be feasible in terms of executability and costs. Technical/practical solutions in the produced design should be based on verified facts or prior experience, or on extensive expert knowledge. Depending on the nature of the restoration case (e.g., small-scale habitat improvement vs. large-scale dam removal), detailed planning and designing can be very different in extent and can be carried out either by the project team or by external consultants. If external services are needed, financial resources need to be reserved and a competent actor chosen directly based on previous experience and references or through an official procurement process. Importantly, adequate expertise needs to be guaranteed for the planning and designing process. A faulty design can ultimately lead to project failure. And finally, stakeholder participation and acceptance promote successful designing and minimise risk of conflicts during implementation.

Long-term financial planning and resources: Good financial planning and adequacy of funds promote success of river restoration projects. To make a project run efficiently and effectively, it is important to have good financial planning. This involves equitable allocation of funds so that adequate resources are reserved for undertaking all phases and required tasks in a project. Importantly, allocating funds for monitoring and evaluation phases is often neglected but important for knowing how the project succeeded and if the restoration brough desired improvements.

Human resource planning for upcoming project phases: Availability of adequate and appropriate human resources is very important for the success of a river restoration project. Therefore, identification of appropriate project teams for the upcoming project phases, namely, implementation and monitoring/evaluation, should be an integral part of the project planning process. The human capital should be assessed in terms of personal qualities such as capacities for teamwork, coordination, leadership, etc. as well as the necessary knowledge and skills related to the specific project roles. The project team can have members from the implementing agency alone, or also include external actors such as experts, entrepreneurs, social organizations, etc. Even some relevant stakeholders may be included in one or more project teams, depending upon the need and personal competence. The human resources identified should be adequately supported through efficient financial planning. On the whole, the selected human capital should comprise cohesive teams comprising an array of relevant actors possessing necessary knowledge and skills and including good leadership and coordination skills.

Impact assessments and permission procedures: Project preparatory work may contain mandatory permission and assessment procedures. Knowledgeable and correct handling of these facilitate smooth progress of the project. These procedures be e.g., EIA, permit for construction in water, a construction permit or dispensation from regulations in areas protected for different reasons (high nature or cultural heritage values, Natura 2000, beach protection act, ancient monuments and archaeological areas act), and required necessary administrative steps. For instance, if a landowner or operator of a hydroelectric power plant or other type of activity has a legally valid permit for these activities, a court ruling may be necessary for obtaining required permits. These procedures are often very time consuming (from months to more than a year) and it is necessary to contact the competent authorities in time. To carry out needed impact assessments for the restoration measure is an important practice promoting the success of a restoration project. Properly conducted environmental or social impact assessments do necessarily not only fulfil a legal obligation (when mandatory). These can also support and improve further project planning through complementing information about the most central environmental and socio-economic factors, or by revealing weaknesses or insufficiencies of the planned restoration measures in relation to environmental requirements or legislation in force.

Resolution of conflicts of interests: Once the stakeholders relevant to a project are identified and an analysis of their interests is carried out, it is extremely important to address any potential or existing conflicts, and to gain stakeholder confidence and participation. Effective handling of conflicting stakeholder interests and creation of dialogue, inspiration and trust among all involved stakeholders are important for successfully implementing the planned restoration activities. When a restoration project has minimum unsolved conflicts of interests it will usually face only little if any opposition, which promotes a successful project outcome. Unsolved conflicts of interests have a negative effect on the possibilities to carry out a restoration and can effectively slow down the progress of a project and in some situations even lead to project failure.

Preparation of implementation phase: Thorough preparation of the implementation of a restoration measure is important factor contribution to success. The implementation needs to be prepared timewise and by securing required workforce and competence. The practical implementation work is to be carried out by a designated operator. Depending on the case this can be e.g., a construction company or a group of volunteers. If a commercial operator is needed, this should be prepared well in advance by organising a hiring process based on previous experience and references or through official procurement. Also, even if the practical restoration work will be conducted by the project team itself or with the help of volunteers, it needs to be prepared by acquiring and transporting needed machinery, tools and materials. These needs can vary and depend on the nature of the restoration location and measure to be taken. An example of needed materials and equipment for a habitat restoration of a stretch in a small-scale Baltic Sea sea trout river is given in Box 8. Also, the supervision of the restoration measure needs to be prepared. Depending on the nature of the project, supervision can be done by the project group itself or it might require an external construction supervisor, who needs to be procured in advance. Additionally, some restoration measures might need to be conducted under surveillance of a supervising authority (e.g., when an environmental permit with some implementation criteria is needed), which also might need to be arranged.

<u>Planning of monitoring and project evaluation</u>: Alongside, the planning and preparations of the implementation of the restoration measure, also planning of project assessment and evaluation needs to be done. This involves planning a monitoring strategy – including choice of suitable indicator – for evaluating ecological effectiveness of the restoration measure. The choice of the indicator to be monitored is dependent on the ecological entity targeted by the restoration, e.g., improving migration or increase spawning possibilities, for revitalising the fish population. Monitoring should be planned for the restoration location to be started well in advance and to continue after the intervention. Optimally, monitoring should be carried out for the same duration also in some non-affected reference sites in the same and other similar rivers. Such set up enables a before-after-control-impact (BACI) analysis that is a useful tool for examining a specific effect in a complex environment. Different countries or funding organisations might have specific obligations and rules regarding organisation of monitoring of river restoration effects, which in those cases should be followed.

In practice, in restoration projects with the aim to improve the ecological settings for reproduction/production, monitoring that quantitatively measures abundance of offspring is used. This can be done by electrofishing and different analytical schemes for parr density estimation through removal sampling (see Chapter 4). There can also be other/additional methods for monitoring the restoration effectiveness. E.g., when a fish pass has been built to improve migration, to assess the direct effectiveness of the fish pass, monitoring the number of ascending spawners (and also descending smolts to some degree) is the correct monitoring method to which there are different technical solutions. Similarly, to assess spawning habitat improvements per se, the most direct measure is to monitor spawning events or spawning success (given that there is a sufficient supply of potential spawners in the river), which can be done through counting of spawning redds or trough monitoring of hatched larvae. To acquire a full understanding of the functionality of a production habitat (and problems thereof), all different life-stages should optimally be monitored. However, in reality this is seldom possible as it is often a matter of balancing utility of the monitoring with the available resources. An example of a good ecological monitoring scheme to assess the impact of restoration in a small-/medium-sized sea trout river in the Baltic Sea region is described in Box 9. In addition to ecological assessment also other aspects of project sustainability and success can be assessed, for instance project management and stakeholder relations, and need to be planned accordingly.

Box 8. Suggested materials and equipment for a habitat restoration of a stretch in a small-scale Baltic Sea sea trout river (200 m stretch).

Materials

- Approximately 200 tonnes of stones of various size (~15–20 truckloads)
    - 1/3 stone 4–8 cm
    - 1/3 stone 10–15 cm
    - 1/3 stone >40 cm
- Logs with diameter >30cm
- Trees (e.g., alder, willow) to plant to create shade
- Canvas and gravel to build a transport road

Equipment and machinery

- Tools and equipment
    - Shovel
    - Mattock
    - Iron-bar lever
    - Branch saw
    - Chainsaw
    - Bucket
    - Waders
- Machinery
    - Crane truck with a long enough arm to deliver the stones directly into the river
    - Track-borne excavator
    - Wheel-borne excavator
    - Dump trucks

Box 9. An example of a good ecological monitoring scheme to assess the impact of restoration in a small-/medium-sized sea trout river in the Baltic Sea region.

General

- For sea trout use parr (0+) occurrence and density as a primary indicator for production
- Additional monitoring of ascending fish, spawning redd counts, hatched larvae, post-larval juveniles, or smolts, can be applied instead or as a complement to parr density estimation when justified (dependent on the restoration objective)
- Plan a BACI design (Before-After-Control-Impact; Green 1979, Smokorowski and Randall 2017)
- Use preferably some removal sampling based parr density estimation method (e.g., Zippin method; Zippin 1956, Bohlin et al. 1989)

Before

- Visual inventory of spawning areas after spawning season to count redds and obtain a sense of the number of spawners
- Electrofishing for estimating parr density (Bohlin et al. 1989) at the site where restoration is planned, or downstream and upstream migration obstacles planned to be removed
- River habitat survey, whole river
- Survey of other river flora and fauna (benthic invertebrates, aquatic macrophytes, diatoms)
- Water quality (nutrients, hazardous compounds, and pH)
- Cultural heritage value

After

- Visual inventory of spawning areas after spawning season to count redds and obtain a sense of the number of spawners
- Electrofishing at the same sites as before. Yearly for 2–6 years
- Pit-tag monitoring or fish counter (especially at a migration solution)
- River habitat survey, at the site of restoration, but also upstream and downstream to record changes in fluvial processes like erosion and sedimentation
- Survey of other river flora and fauna (benthic invertebrates, aquatic macrophytes, diatoms)
- Water quality (nutrients, hazardous compounds, and pH)
- Cultural heritage value

7.1.4 Phase 4: Implementation

The implementation phase in the restoration process contains the execution of the chosen restoration measure. This includes the practical work of improving the problematic aspect in focus and improving the condition in the river according to the plans. The practical work is carried out by a designated operator, optimally under surveillance of a project supervisor. The implementation phase starts with the onset of the practical work at the restoration site and ends when the work for the planned measure is finalised, inspected, and approved.

Optimum conditions

Good plan of action: A detailed and precise plan is essential for achieving project success. The plan for a restoration project should contain clearly defined goals and targets, all necessary methods and processes, precise time plans, clear workflow charts, and resource allocation (human, financial and other) for all phases of work. The plan should reflect responsiveness to stakeholder interests and also include their inputs and, if possible, their appropriate engagement. Concrete incorporation of local cultural, historical, recreational, or other values in the plan can promote success.

Effective technical design: An effective technical/practical design for the restoration measure needs to be in place as basis for the implementation. Depending on the nature of the restoration measure, the design documents should include necessary construction drawings and supporting detailed descriptions and instructions following common formats to be interpretable by the implementer.

Secured permissions, competence, workforce, materials and equipment for practical implementation: To be acknowledged also in the plan of action, for effective and efficient implementation, needed permissions, competence, workforce, materials and equipment should be secured. These needs can vary and depend on the nature of the restoration location and measure to be taken but include at least all required environmental, construction and other relevant permissions, a designated operator who carries out the restoration, a construction supervisor as needed, as well as restoration materials and construction equipment.

Necessary actions

Implementation of restoration measure:

Correct implementation of the restoration measure is as important as a good design. The end results after the implementation – i.e., the restored river – is the realisation of the chosen action against the identified ecological problem in the river and is thus the crown of the whole project. Optimally, the implementation is thorough, of high quality, effective and efficient, following the created design and agreed schedule. The practical work is carried out by a designated operator (e.g., a construction entrepreneur or a group of volunteers), optimally under surveillance of a project supervisor. During the implementation continuous follow-up of the progress and quality is important for securing correctness and for intervening in case of problems. Good leadership with continuous guidance to the implementing entrepreneurs and right competence and experience within the implementing group contributes to a successful process. To facilitate a good implementation, well-functioning communication between the operator of the practical work and the rest of the project team is important. Likewise, important is to maintain established transparent and active stakeholder communication also during the practical work stage, to prevent any sudden conflicts that could hamper and delay the practical work. For instance, if flaws in the plan appear and changes are needed during the construction, all involved stakeholders must be informed to gain their agreement before work can proceed.

7.1.5 Phase 5: Post-implementation

The final phase in the restoration process includes a number of post-implementation tasks and activities. One of these is the assessment and evaluation of the project. After project assessment, the final phase also includes communication of project finalisation and results. Depending on the nature of the restoration in focus, continuous future maintenance measures might be needed to secure long-term sustainability of the restoration solution. Also, taking into account the results from the project assessment, further or additional measures might be required in the context of adaptive management, which in turn can inform future projects.

Optimum conditions

Effective plan for monitoring and evaluation: Already during the planning phase of the project, a monitoring and evaluation strategy should have been developed. For monitoring and evaluation of ecological effectiveness of the restoration measure, suitable indicators have been chosen, monitoring sites and scheme have been established, and optimally monitoring has been started already before the restoration intervention (Box 9). In addition to ecological assessment the project evaluation plan can also contain other aspects of project sustainability and success, such as successfulness of project management and stakeholder relations.

Necessary actions

Operation and maintenance of interventions: After implementation of the restoration measure, it is important to ensure efficient operation and necessary maintenance in the long term. Efficient and correct operation is especially relevant regarding technical/mechanical solutions but also for instance regarding water regulation for sufficient flow in a fish pass. Some reoccurring maintenance might be needed to sustain operability and effectiveness, both regarding technical/mechanical solutions and habitat restoration.

Monitoring and evaluation of the project: Evaluation of the project is an important, but too often overlooked task, that is centrally important for informing about the success of the project. Evaluation should be done following the project evaluation plan that has been, or should have been, established already during project planning. The evaluation should be based on monitoring of relevant indicators reflecting the project aims. Of these, the ecological targets are often the primary ones and thus monitoring of suitable ecological indicators (e.g., parr density) before and after implementation is imperative for evaluation of effectiveness of the measure and on its part the success of the project. Evaluation of secondary objectives (e.g., provisioning recreational value or maintaining cultural heritage value) by using suitable indicators, provides additional dimensions for the evaluation. A comprehensive restoration project assessment and evaluation can also address project level factors, such as project leadership and management, stakeholder relations and acceptance, and project communication. Finally, a confirmation of a successful project, as improvement of the river can increase the awareness of the local population on the necessity to participate in the protection of migratory fish, rivers, and nature protection in general, and through that increase interest, positive attitude and future engagement in similar projects.

Communication of project results: Communicating and dissemination project results to stakeholders and the general public creates visibility and positive publicity that can increase general support and goodwill for the project and river restorations in general. Communicating results and important lessons that can also inform future restoration projects.

Adaptive management: Project assessment and evaluation inform about how plans were realised and if objectives were fulfilled. If problems are encountered, the reasons should be known, and necessary corrective measures can be applied. This sort of adaptive management is useful for eventually reaching the goals, instead of settling with failure. The process can also acquire important lessons that can inform future restoration projects.

7.1.6 Continuous important settings and practises

Important settings

Political and societal context: A river restoration project always operates in a given political and societal framework that ultimately defines possibilities and imposes constraints for the project. This occurs through laws and regulations, but also through established moral perceptions, valuations and common practices, steering the project objectives and activities throughout the project.

Sufficient resource availability: Resource availability needs to be sufficient throughout a restoration project. Adequate funds on a long-term basis are essential for sustainability and success of any river restoration project. Needed funds must be secured before the project can start and maintained and managed soundly throughout the project. Funds are needed, e.g., for project staff costs, administration and permission procedures, hiring of consultant expertise for planning and design of restoration measure, for material cost and practical restoration work, monitoring and project evaluation work, maintenance needs, and project communication. In addition to adequacy of funds, knowledge and skills can also be seen as centrally important required resources of a restoration project. To achieve a successful restoration project, relevant knowledge and skills are needed for instance for project management (including finances and budget), legal and regulatory aspects, and communication, in addition to the essentially required expertise in river restoration measures, including understanding of river hydro-morphology, biology/ecology, and sometimes engineering. These non-financial resources likewise need to be managed and maintained with care throughout the project.

Cohesive and dedicated project team: The composition and synchrony of the team driving the restoration project is important for the project's success. The project team can have members from the implementing agency alone, or also include external people such as experts, entrepreneurs, social organisations. Importantly, appropriate competencies, good leadership, effective communication, and strong motivation for the work is needed. A well-managed and coordinated cohesive project team possessing necessary knowledge, experience, and skills, brings clear added value for the project through preparedness and ability to address any upcoming aspect of the project or encountered difficulties. However, project teams may not be fixed over all the project phases. The team involved in the preliminary survey may be different from that responsible for project planning and/or implementation. Finally, one or more different teams may be given the responsibility of post-implementation activities of maintenance, monitoring and evaluation. Thus, the continuity of specific members in the team is not the concern. What is important is that the assigned team possesses the qualities and characteristics noted above.

Important practices

Decision-making: Well-functioning decision-making promote success in a restoration project. Decision-making is a process which occurs repeatedly in any project through different stages. How decisions are made, who exercises authority and who contributes to decisions and to what an extent, is important. Participatory decision-making, where stakeholders are consulted and their perspectives and interests valued, arriving at strategic decisions tend to succeed. Also, within the project team a participatory style of decision-making promotes success.

Stakeholder management and engagement: Involvement of a diverse assemblage of stakeholders can appear to overly increase the complexity and workload in the project, but usually the benefits to be gained will compensate for potential negative sides. Benefits of broad multi-stakeholder involvement can involve the provision of new and diverse perspectives, experiences, and knowledge, as well as the potential for wide acceptance of the project. Building trust and acceptance among stakeholders for the project is extremely important throughout a river restoration project and contributes to success. To gain and maintain stakeholder confidence, participation and sometimes even a sense of ownership will not only help addressing any potential or existing conflicts but can also provide support and added value to the sustainability of the project, for instance in form of wide and long-term acceptance, outreach facilitation, resource support for implementation and maintenance, and voluntary monitoring and supervision of the restoration location. Thus, managing stakeholders involves attaining active and continuous involvement and engagement, (pro)active resolving of conflicts, and promoting coordination with and among stakeholders. Inability to do so or ignoring the same can prove to be detrimental for a project's fate. The most important tool for stakeholder management and engagement is communication to and with stakeholders (see below).

Project communication: Continuous communication is an important project process that may heavily influence the project fate. Clear, regular and effective communication is essential within the project management team as well as with the external stakeholders and the public. Effective internal communication facilitates good collaboration and coordination within the project team. Stakeholder communication and information dissemination throughout the project facilitates stakeholder management and engagement and can help minimise the risk of opposition. Effective communication with local stakeholders can create inspiration and trust to better anchor the restoration work in the community. Public informing of the project's progress and dissemination of results creates visibility and positive publicity that can increase general support and goodwill towards the project and restoration work in general.

7.2 Recommendations for successful river restoration projects

Regarding recovery action and measures to improve salmonid rivers in the Baltic Sea region, the following general recommendations are given in the spirit of the highly relevant HELCOM Recommendation 32-33/1:

- Action for the recovery of naturally reproducing salmonid populations needs to be taken.
- Original strains as well as weak and threatened salmonid populations should be prioritised.
- Free passage for fish through the rivers should be provided.
- River waters and habitats should be restored towards *a salmonid habitat in good state* (HELCOM Rec. 32-33/1) when justified.
- A natural life cycle of salmonids should be ensured, and restoration actions to enable natural reproduction and self-sustaining populations are to be preferred before fish stocking.
- Fishing rules and management practices of river fisheries need to support the above-mentioned recovery actions.

Based on the identified best practices for river restoration projects key messages have been extracted and presented as a Recommendations for successful river restoration projects especially for sea trout rivers in the Baltic Sea region. A summary list of the Recommendations is given in Box 10. The Recommendations are not presented in order of priority.

Box 10. Summary list of Recommendations for Baltic Sea river restoration projects

1. A successful restoration project is recommended to thoroughly follow order, tasks and duties of the sequential 5 phases of the restoration project process.
2. A well-managed and coordinated cohesive project team is needed.
3. Rivers and locations for restoration need to be selected carefully based on informed criteria.
4. A restoration process must be preceded by obtaining of sufficient knowledge on the current condition and settings of the river to be restored.
5. Understanding stakeholder's stakes and organising their engagement is critical for the success of the project.
6. Adequacy of funds and other resources on a long-term basis needs to be secured before the project can start.
7. Restoration measures should be chosen based on their expected utility for the ecological objective relative to the costs, within the possibilities set by resources and legal and practical limitations.
8. Planning and design of the project need to be done with great care, and these must be preceded by sufficient preparatory work.
9. Implementation of the restoration plans and designing needs to be correct and effective.
10. The post-implementation processes of monitoring and evaluation need to be carried out for determining the project success and to enable adaptive management of the river.

1. Process and progress of a restoration project

A river restoration project must be seen as a process where a series of planned tasks are undertaken, ordinarily within a specified time period, to help initiate or accelerate the recovery of the riverine ecosystem with respect to its health, integrity and sustainability. Thus, a successful restoration project is recommended to thoroughly follow order, tasks and duties of the sequential phases of the restoration project process. The following 5 essential project phases must be completed in the same order as follows:

- *Initiation*: where a project idea is formulated in response to identified needs. This requires incentive (policy, legal, economic or social/cultural), suitable river, and known ecological challenge and identified causes and reason for it. This early formulation envisions a desired improved future state of the river.
- *Preliminary survey*: is conducted to establish the priorities, objectives, and strategy of the project. Potential solutions and alternative measures must be explored and compared in terms of the needs, possibilities, restrictions and estimated effectiveness. Needs correspond to the problem and the desired change in the river, possibilities and restrictions include enabling and hindering factors related to inter alia availability of resources and time, policies and legal frameworks in force, and stakeholder relations and consent. Finally, the preferred solution or solutions are chosen for the project for further development.
- *Planning*: which involves designing of the chosen restoration measure(s) and planning for its implementation, including the financial and human resources. Any preparatory work such as mandatory permission procedures (e.g., EIA) and

administrative steps must be completed. Potential or actual conflicts of stakeholder interests must be resolved. Finally, a time- and staffing plan is prepared, followed by planning for project maintenance, monitoring and evaluation.

- *Implementation*: which comprises the execution of the chosen restoration measure in accordance with the plans. The implementation phase starts with the onset of the practical work at the restoration site and ends when the work for the planned measure is finalised, inspected, and approved.
- *Post-implementation*: includes a number of tasks to ensure long-term sustainability of the project and its adaptive management. This may comprise the continuous future maintenance of the restoration measures as also monitoring and evaluation of the project. Communication of the project results and any additional measures undertaken for adaptive management are also included.

2. Project team

A well-managed and coordinated cohesive project team is needed. The project team should comprise an array of relevant actors who, in turn, could include the staff from the implementing agency, entrepreneurs executing specific restoration tasks, experts and specialists in advisory capacity, and representatives from external stakeholder groups, including the local community. The following characteristics are important:

- Possession of necessary knowledge, experience, skills, and other appropriate competencies in the team.
- Preparedness and ability of the team to address any upcoming challenges in the project.
- Strong leadership and coordination skills in the leader.
- Dedication and genuine passion for the work is needed.
- Effective communication within the team is crucial.

3. Well-justified choice of restoration target

Rivers and locations for restoration need to be selected carefully based on informed criteria, to achieve optimal impact and best values for available resources. The following general criteria are important:

- Environmental degradation due to human impact
- Unique trout population
- Presence of red-listed species
- High potential for increased trout production
- High potential for increased biodiversity
- High expected impact of restoration relative to cost
- Positive attitude of and preliminary acceptance by stakeholders
- Supportive legal conditions
- Positive or neutral impact on cultural heritage or recreation value
- High technical feasibility

4. Sufficient background knowledge

A restoration process must be preceded by obtaining of sufficient knowledge on the current condition and settings of the river to be restored, including comprehensive information on hydrological, environmental, social/cultural or other aspect relevant for obtaining an adequate understanding of the state of the river. This comprises knowledge about:

- The river drainage area.
- Large-scale hydro-morphological qualities.
- Quality of specific river habitats.
- Water quality and quantity issues.
- River connectivity (by identification of all migration obstacles).
- Status of river biota (e.g., origin and status of sea trout population and other biodiversity elements).
- Pressures and problems in the river and river basin that likely affect the target fish populations.
- Cultural, historical, recreational values, and economic values and interest that might conflict with the restoration objective.

5. Stakeholder analysis, involvement and management

Stakeholders can play a key role in a river restoration project and hence understanding their stakes and organizing their engagement is critical for the success of the project. The stakeholders may be diverse, including different governmental/administrative agencies (including transboundary), landowners and/or 'water owners', fishing and nature protection NGOs, sport fishing associations, private actors in tourism/fishing tourism sectors, companies benefitting from hydropower or other industrial projects, and even local citizens' forums.

With regard to stakeholders, the following actions are important:

- Undertaking a detailed stakeholder analysis during the preliminary survey phase in order to identify them and assess their interests.
- Taking appropriate action to resolve any conflicts of interests well before taking restoration decisions and finalizing plans.
- Maintaining continuous communication with them throughout the project and building a relationship of trust.
- Seeking their participation in the different project processes in order to gain confidence and benefit from their strengths, knowledge and experiences.

6. Resource availability

Adequacy of funds and other resources on a long-term basis need to be secured before the project can start. Financial planning needs to be done and funds allocated at least for the following costs:

- project staff costs
- administration and permission procedures
- consultant expertise (for planning and design)
- materials and equipment
- practical restoration work (entrepreneur costs)
- monitoring and project evaluation work

- maintenance needs
- project communication

In addition to adequacy of funds, also the following relevant knowledge and skills need to be available:

- project management skills and competence (including leadership, finances and budget)
- necessary expertise in river restoration measures (including understanding of river hydro-morphology and biology/ecology)
- knowledge on administration and permission procedures
- expertise on relevant law and regulations
- adequate knowledge on engineering

7. Selection of restoration measure

The best measure to be taken should be chosen based on its expected utility for the ecological objective relative to its costs, within the possibilities set by resources and limitations. The selection of the most appropriate restoration measure should be made carefully following a thorough assessment of the various context-based factors relevant for the project and based on existing inventories or expertise on alternative solutions available. The following generic selection procedures for two common restorations types are important:

Migration obstacle

1) Complete removal of the migration obstacle and restoration of the river to the state before the object was constructed.
2) Partial removal of the migration obstacle.
3) Nature like fish pass, a bypass allowing spawning ad biological diversity in the fish pass.
4) Technical fish pass.

Habitat restoration

1) Rehabilitation: Restoration of a rivers processes so that its morphology can revert to a natural condition. Example: restored base level by constructing an artificial determining section (Grade Control Structure).
2) Restoration**:** Restoration of a rivers shape and processes according to its original condition.
3) Habitat improvement**:** Adding structures to improve habitat or prerequisites for a certain species or group of species.

8. Preparation, design and planning

Planning and design of the project need to be done with great care, and these must be preceded by sufficient preparatory work. Important considerations here are as follows:

- Preparation for the project must be thorough and elaborate. This includes acquiring and exploring background information on the ecological, hydro-morphological and societal aspects of the river, and conducting a preliminary survey to establish the priorities, objectives, and strategy of the project including identification and choice of solutions. Also, an exploration of available resources and time, policies and legal frameworks, as well as foreseeable potential difficulties and challenges in carrying through the project is needed.

- Further planning and design of the restoration solution needs to meet the set restoration objectives effectively yet be feasible in terms of executability and costs. Chosen solutions within the design should be based on verified facts or prior experience, or on extensive expert knowledge.
- Detailed planning is needed for the project encompassing financial, human, and technical resources. Planning must not only concern the implementation of the restoration solution *per se* but also include the post-implementation phases, namely, long-term maintenance of the restoration measure, project monitoring and evaluation, as well as any necessary adaptive management.

9. Correct and effective implementation

   Implementation of the restoration plans and designing must be correct and effective. The implementation should be thorough, of high quality, effective and efficient, following the created design and agreed schedule. The practical work should be carried out by a designated operator possessing required competence and expertise, optimally under surveillance of a project supervisor. Continuous follow-up of the progress and quality is important for securing correctness and for intervening in misconducts. Good leadership of the implementation work and well-functioning communication between all parties involved is needed.

10. Monitoring and evaluation of the project

    After a project has been implemented, the post-implementation processes are critically important for determining the project success. The following processes are important here:

    - Project monitoring helps assess quality and effectiveness of the ‘performance’ in the project implementation. The objective is to track and identify the gaps and to improve the implementation to achieve the project goal and objectives. Monitoring involves a continuous and systematic process of observation, systematic documentation, and critical reflection, and helps in adaptive management and learning as per needs. Thus, monitoring may help observe the effectiveness of the restoration measure(s) in place vis-à-vis the ultimate project goal and apply timely correctives.
    - Project evaluation helps assess quality and effectiveness of the ‘outcome’ of the project implementation. It examines what progress has the project made towards achieving its objectives. Thus, evaluation of the project must be done after the passage of an adequate amount of time during which the impacts of the restoration are expected to have taken shape.
    - Project evaluation includes an assessment to examine the achievement of the expected outcomes and any other unintended positive or negative impacts. The ecological effect evaluation should be based on monitoring covering at least the following aspects:
        - Optimally follow a BACI design

- Monitoring of primary target indicator (for sea trout, parr (0+) density as indicator for production)
- Additional monitoring of primary target using other indicators (for trout e.g., monitoring of ascending fish, spawning redds, hatched larvae, post-larval juveniles, or smolts)
- River habitat survey (hydro-morphological evaluation on whole river scale)
- Survey of other river flora and fauna (benthic invertebrates, aquatic macrophytes, diatoms)
- Monitoring of water quality (nutrients, hazardous compounds, and pH)

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