WISŁOKA WITHOUT BARRIERS

Report on the implementation of the project „Removal of migration barriers for aquatic organisms on the Wisłoka River and its tributaries - Ropa and Jasiołka"

The State Water Holding Polish Waters
Regional Water Management Board in Krakow

2021

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PROJECT BENEFICIARY
National Water Holding Polish Waters
Regional Water Management Board in Kraków
ul. Marszałka J. Piłsudskiego 22, 31-109 Kraków

PREPARATION OF DESIGNS AND AUTHOR'S SUPERVISION
Ośrodek Usług Inżynierskich STAAND Sp. z o.o

PROJECT MANAGEMENT NATURAL SUPERVISION, PROMOTION
Roman Żurek Zakład Badań Ekologicznych

INVESTOR'S SUPERVISION
Biuro Obsługi Budownictwa „Bień" Jan Bień

EXECUTION OF WORKS
Przedsiębiorstwo Produkcyjno-Usługowo-Handlowe WOLIMEX

DELIVERY AND INSTALLATION OF MONITORING DEVICES
Zakład Produkcyjno-Handlowy PIWI

DESIGN OF MIGRATION CORRIDORS
P.P.H.U AdEko s.c.

SUPERVISION OF THE CONSTRUCTION OF THE MIGRATION CORRIDOR
F.U.H.P „AQUA EKO" Stanisław Brzęk

HYDRAULIC MONITORING
University of Agriculture in Krakow

AUTHORS OF THE TEXT
Roman Żurek, Karol Ciężak, Roman Konieczny, Małgorzata Siudak

PHOTO AUTHORS
Drone images Roman Żurek Zakład Badań Ekologicznych, other photos: arch. PGW WP RZGW, K. Ciężak, M. Jelonek, R. Konieczny, M. Siudak, R. Żurek

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Removal of migration barriers on the Wisłoka River and its tributaries - Ropa and Jasiołka

Purpose of the Project

The main aim of the project was to restore the possibility for fish and other aquatic organisms to move freely up and down the Wisłoka River and its tributaries. It was achieved by supplying the migration barriers (weirs, steps, and sills) built in the last centuries with effective fish ladders. At the same time, it fulfilled the strategic goal of the Water Management Plan in the Upper Vistula River Basin, to improve the ecological status of the waters of these catchments.
The experiences gathered during the project are valuable material for the preparation of similar plans for other rivers.

Project Genesis

One of the features of the river's natural environment is the lack of barriers that prevents migration of aquatic organisms and inhibition of sediment movement. Partitioning the river with artificial barriers significantly disrupts the ability of fish to search for food, hiding places, or spawning places, which affects their numbers and condition, and in extreme cases, access to spawning grounds in the upper parts of the rivers which can lead to the extinction of entire populations. There have been no two-environmental fish in Wisłoka for a long time, including salmon, sea trout, and sturgeon. Recent studies have shown a large diversity of species on adjacent, but separated by weirs or programs, sections of the river.

Basic Project Tasks

- Modernisation/construction of seven ladders on steps constituting migration barriers for fish
- Monitoring the effectiveness of fish passes - assessing whether the fish are able to overcome them
- Environmental supervision over the implementation of investment tasks
- Information and promotion activities

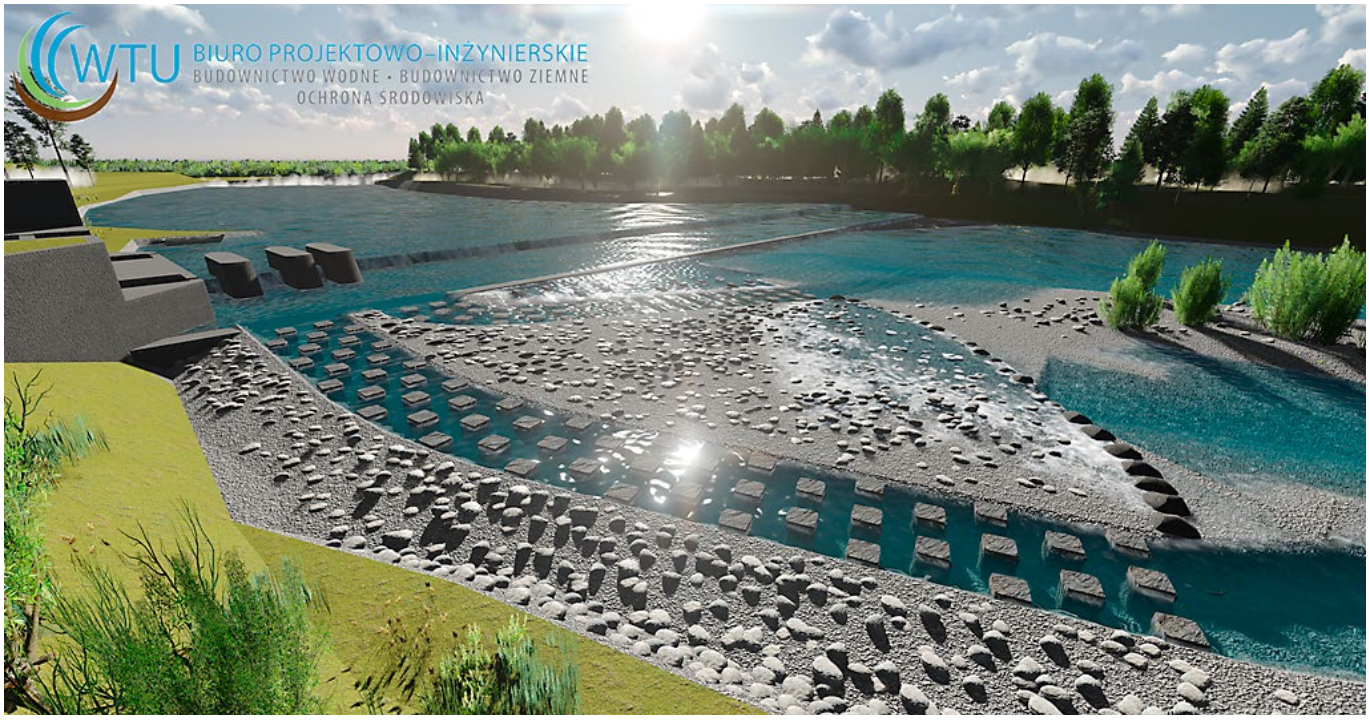
Basic Requirements for Fish Passes

The design was preceded by a thorough inventory of hydrotechnical buildings and consultations of technical solutions. It ensured the elimination of migration barriers for aquatic organisms while maintaining the existing functions of the Modernised facilities. Solutions "close to nature" were adopted, imitating the conditions in a natural river.
The projects considered the migration requirements of various fish species including sizes, swimming speeds, typical behaviors, and migration dates.
It was assumed that the technical solutions were to ensure optimal migration conditions, namely:

- The ability to overcome the barriers (up to several hours) quickly and safely by all the development stages of fishes occurring in rivers and streams within the operational flow of the device (i.e. in the range of flows from the lowest to high, equal to two and a half times the average flow calculated a multi-year period)

From left: nase, carpathian barbel

Perch



Visualisation of the Dębica fish ladder project by WTU LLC - contractor for construction documentation in the project

- Ensuring minimum depths for various fish species in the fish pass basins, from 0.4 m (brown trout) to 1 m (sturgeon) at the lowest flows in the long term
- Ensuring minimum transit depths in crevices, overflows, and inlets of the designed devices, from 0.2 m (brown trout) to 0.3 m (barbel, bream, perch, pike, salmon, sea trout) at the lowest flows of many years.

The local and location conditions as well as the needs of the facility owner were also considered. As a result, the construction of a rapid was designed instead of the existing weir in five cases and the bypass channel - in two cases.

Earlier Stage

The planned activities were a continuation of the project "Restoring the permeability of the ecological corridor of the Wisłoka River and its tributaries" implemented in 2010–2015 by the Regional Water Management Board in Kraków.
Within the framework of the project, the middle section of the river was made accessible (two barriers in Jasło were made accessible to fish), gravel habitats for fish species that choose gravel or rocky bottoms for spawning grounds were restored in the section from the weir in Mokrzec to Pustków, and salmon and vimba bream stocking was carried out.

Fish pass of a rapid type next to the existing weir - Jasło I

Two vertical slot fish pass next to the existing weir - Jasło II

Seven Fish Ladders

The project involved construction, or modernisation, of seven fish ladders on the weirs in the following towns: Dębica and Mokrzec on the Wisłoka River, Gorlice (two fish ladders) and Ropica Polska on the Ropa River, and Jedlicze and Szczepańcowa on the Jasiołka River.

The map below shows the location of all modernised fish passes that were also implemented in the first stage of the project in Jasło. As a result, the 254 km long river corridor (Wisłoka with Ropa and Jasiołka) was made unobstructed.

Location of fish ladders on the Wisłoka and its tributaries

1

FISH PASS IN DĘBICA

River: Wisłoka (km 56 + 180)
Fish Pass Type: Technical fish pass and rock ramp
Construction Cost: PLN 1.82 million

Reason for Modernisation. In order to stabilise the water table at the intake for Tire Company Dębica S.A., a 100 m long damming weir was built many years ago, damming the water up to a height of 2.2 m. The upper weir has a Creager spillway that is 11 m below the upper weir is a second and the lower weir was made as a Larsen wall. On the right bank, there is a water intake and an almost 40 m vertical slot fishway. Over time, the fish ladder has ceased to function due to bottom erosion.

Fish Ladder Description. As part of the investment, the existing technical fishway was modernised and a rocky ramp was added to it at the right bank right below the existing second weir. The reconstruction of the slotted fish pass consisted of widening the slots, lowering the bottom in its chambers, and forming a constant slope of 2.29%. The entrance to the fish ladder (from the lower water side) is currently a reinforced concrete ramp with a stone lining. The rock ramp has a quadrant circular plan with a radius of 40 m and a gradient of 1:20. The inlet of the fish ladder channel on the downstream side has been carved into the closing dike. In order to enable fish migration from all areas of the riverbed, two independent channels were constructed in the ramp body, concentrating most of the water during low flows. These channels are directed from the slotted pass, oblique to the river axis.
In order to dissipate the energy of the water flowing over the existing weir and to protect the rock ramp from icefloes, a reinforced concrete slab with concrete chute blocks was constructed in the middle of the weir.

Changes Made to the Design. In the course of the project, the technology of fastening boulders at the bottom slab of the ramp on the right bank and the other one, directed obliquely to the river axis, was changed. The connection was made with rods embedded in drilled holes and fixed with a chemical anchor. In order to increase the abrasion resistance of the reinforced concrete bottom slab and the chute blocks, they were made with basalt aggregate. Additionally, due to fear of damaging the technical fishway (slotted pass), the size of heavy stone surcharge at the inlet to the fishway was more than doubled.
During the construction of the rock ramp, an innovative method of arranging boulders in the stone ramp below the body of the weir was proposed - the texture of the arranged boulders of the stone ramp between the right bank and the main channels of the fish ladder was changed. The change consisted of, instead of a flat surface, a saw-tooth shape surface of overlapping stone slabs about 0.5 m thick was made. The boulders were arranged in a "herringbone" pattern on the ramp plan. This arrangement of slabs has resulted in the self-creation of baffles and pools (i.e., lateral areas with lower water velocities, which provide opportunities for 'weaker' or smaller fish species to pass the ramp).

Laying a rock ramp below the technical fish pass

The barrage in Dębica before the modernisation of the fish pass

The interior of the technical fish pass on the right bank

Rock ramp in Dębica after realisation

FISH PASS IN MOKRZEC

2

River: Wisłoka (km 69 + 700)
Fish Ladder Type: Bypass channel
Construction Cost: PLN 9.32 million

Reason for Modernisation. In order to rehabilitate the areas devastated by gravel extraction, a rubber sheeting weir was built in Mokrzec. The water dammed up by the weir covered the excavations, creating a 230 ha reservoir used for recreation. The weir allows for changes in damming height from a minimum crest level of 1.9 m to a damming level of 4.5 m with a water-filled rubber bladder. Until the construction of the small hydroelectric power station at the weir on the right bank, there was, and still is, a pool pass on the left bank. Due to poor design, the entrance to the fish ladder was above the water surface. Stopping the transport of dragged sediment through the reservoir caused bottom erosion below the dam. This fishway has never operated.

Fish Ladder Description. The 430 m fishway bypasses a weir on the right bank of the river next to the Small Hydroelectric Power Station. It consists of 45 pools, two of which are 47 m in size, and a resting pool with a plated stone bed. The barriers of the pools are made of large boulders of different sizes. The average slope of the fishway is 1.6%. Before the exit of the fish ladder into the reservoir, a chamber with fish monitoring equipment was built. The entrance to the fishway on the downstream side is located at the discharge of water from the power plant. Thanks to this, a fish attracting water stream was achieved. The entrance to the fish ladder consists of a 4 m wide reinforced concrete dock with wings.

Changes Made to the Design. In the course of the investment, the method of substructure and sealing of the fish ladder bottom was changed - the thickness of stone riprap surcharge at the bottom and slope was increased. The geogrid with geo-textile and EPDM geomembrane was used for sealing. The rock material forming the baffles of the fish ladder was also changed from granite to sandstone. It was not necessary to use granite blocks as the surface of the baffles is not directly exposed to abrasion by dragged gravel and sand, which would be the case if boulders were placed in the riverbed. It has also become necessary to build a stone embankment on the slopes of the final section of the fishway in order to protect the banks from scouring during floods.

Weir in Mokrzec with small hydroelectric power plant before construction of new fish pass

Final downstream section of the fish pass

Bypass channel with fishway passage in Mokrzec weir after realisation

Multi-tonne huge boulders used to build the fish pass

3

FISH PASS IN GORLICE I

River: Ropa (km 32 + 300)
Fish Ladder Type: Rock Ramp Fishway
Construction Cost: PLN 1.79 million

Reason for Modernisation. The fish pass is to ensure the passage of the fish through a concrete weir, which is to maintain a constant damming level in the water intake for industrial purposes. The weir was equipped with a malfunctioning concrete pool and orifice fish ladder located in its central part.

Fish Ladder Description. The modernisation consisted of the reconstruction of existing permanent concrete weirs located on the right bank and building a fish pass below it in the form of a cascade (half-timbered) rapids. The constructed rapids are 42 m long and entail a system of 3 m long pools. The spaces inside the pools were filled with wedged stone rip-rap. The bottom slope in this part of the structure is 1:25. The rock ramp fishway in the upper section is 14.8 m wide, and in the lower section it widens to 19 m across the entire natural bed. The inlet to the fish pass from the upper water side was made by cutting slots in spillway crest.
Below the rapids, the roughness of the bottom was additionally increased by the construction of a 15 m stone ramp - a stilling basin. At the end of the rapids and stilling basin, along the entire width of the river, large-sized boulders were made of stone, which stabilized both parts of the structure.

Changes Made to the Project. During the implementation of the investment, minor design adjustments were made. There were concerned of the changes made to the material, of which the end apron of the fish ladder was made and its substructure - sandstone boulders. The bottom and left bank escarpment was also protected by rock revetment between the weir-stilling pool and ending buttress. Beyond the end of the fish pass, and the steel fenders at the inlet, the upper water side was replaced with the appropriate profiling of the concrete
Moreover, the bottom and slope of the left bank between the weir-stilling basin and ending current were insulated with stone. Behind the buttress at the end of the fish ladder, the steel bumpers at the inlet on the upstream side were replaced with a concrete sill and boulder cover.

Weir in Gorlice (water intake) before modernisation

Fish passage in Gorlice

Cutting holes in the upper weir during construction

Dry construction works

FISH PASS IN GORLICE II

4

River: Ropa (km 34 + 250)
Fish Ladder Type: Stone ramp
Construction Cost: PLN 0.95 million

Reason for Modernisation. There was a weir between two bridges in the center of Gorlice. The purpose of which were to stabilize the bottom, guaranteeing the safety of the bridges and two sewer lines crossing the Ropa riverbed at its bottom. Weir dammed water up to a height of 1.1 m and constituted a migration barrier.

Fish Ladder Description. As part of the modernisation, the existing low-head dam was removed, and a cascade/baffle ramp was built in its place. Originally, it was to be in the form of an irregular stone ramp, but during the construction, the Municipal Management Board of the Municipal Economy Company in Gorlice resigned from the reconstruction of the sewage collector. This resulted in a change of the formation of boulders on the slipway (instead of a ramp with irregularly arranged boulders, a cascade baffle fishway was made in the central part regular shapes).

Changes Made to the Design. The arrangement of boulders and the method of forming the fish pass basins were changed into regular-shaped ones. Additionally, the bottom substructure of the fish ladder was changed - the bottom armoring was placed on a two-way geo-grid and covered with rock rubble. The thickness of bed and slope stone filling was increased, the number of stone boulders in the fishway itself was also increased.

A rock ramp-type fish pass in Gorlice (city center) after completion

↓ *Driving a Larsen-type sheet pile wall*

Construction site enclosed by sheet pile wall, access road laid on steel tubes

Weir in Gorlice before modernisation

5

FISH PASS IN ROPICA POLSKA

River: Ropa (km 39 + 400)
Type of Fish Pass: Fish ramp
Construction Cost: PLN 3.55 million

Reason for Modernisation. Building nature-like fishways or bottom ramps does not give the same benefits of removing a dam, however, removing a dam is sometimes impossible. The weir in Ropica Polska was built to provide continuous damming at the water intake for industrial and drinking purposes for Gorlice. The difference of the water level between the designed head and tailwater was about 5 m.
The weir consisted of two steps and a bottom wall. The upper step was made of concrete, and the second and bottom step of Larssen sheet pile. The banks between the steps were protected by concrete slabs with a stone rip-rap below the lower step. This weir was an insurmountable obstacle for fish.

Description of the Fish Ladder. As part of the modernisation, only the upper stage was left from the old facility, with cut-outs providing a passage for fish during low water levels. The lower sill and buttress were cut below the planned bottom level. Below the weir, the fish ladder was laid in the form of a stone rapid. The fishway is 114 m long and consists of two main parts. On the right bank, a cascade fish ladder is constructed, consisting of pools made of different sized boulders with slots for fish. Some of the stones were placed slightly lower than the adjacent ones to ensure a varied flow. The central part of the Modernised barrage, on the other hand, has the form of a stone riffle consisting of irregularly placed boulders, allowing the migration of larger fish species.

Changes Made to the Project. The main correction involved limiting the excessively high flow velocity in the fish pass crevices in its upper part, which was found in the current measurements carried out by the environmental supervision. In order to improve the parameters, the shape of the inlet opening was changed, and a few boulders were added, which reduce the water velocity in the initial section of the rapids, at the same time extending the theoretical migration path. Other corrections concerned the technology of making the rapids, changing the material of the boulders from granite to sandstone and verifying the arrangement of the boulders, which was associated with an increase in their number. The fish-pass route was also changed and adjusted to the shape of the shoreline.

Weir in Ropica Polska before modernisation

Construction of a fish pass on the right bank

Rock ramp in Ropica Polska after completion

Adjustment of the upper part of the fish pass - adding boulders

FISH PASS IN JEDLICZE

6

River: Jasiołka (km 19 + 100)
Fish Pass Type: Rock ramp
Construction Cost: PLN 1.81 million

Reason for Modernisation. The modernised concrete threshold was built to stabilize the water level for the intake of Rafineria Nafty Jedlicze S.A. Theoretically, it formed a barrier about 0.5 m high, but due to erosion, the actual threshold was about 1 m high. Above the threshold, the right bank was reinforced with concrete slabs, and the left bank with a stepped retaining wall. The protection at the edges of the riverbed was made of small stones embedded in concrete and had already been badly damaged.

Description of the Fish Ladder. As part of the modernisation works, a fish ladder was built as a rock ramp consisting of different sized boulders. The boulders dam up the water and reduce flow velocities, creating favourable conditions for the migration of aquatic organisms. A depression has been created in the central part of the fish ladder, concentrating flows at low water levels. The exit from the fish ladder (the upper water side) is through a cut in the existing concrete weir. An irregular spillway shape has been designed to concentrate low discharge. At the end part of the fish ladder, a stilling basin with the bottom going under the riverbed was made. It was finished with a buttress of boulders across the width for stabilisation. The banks of the fishway have been armed with plated riprap.

Changes Made to the Design. In the course of the project implementation, the arrangement of boulders in the central part of the fish ladder was changed from irregular to regular. Additionally, the way of making the substructure of the fish ladder bottom was changed - instead of a reinforced concrete slab, a stone armouring placed on a geo-grid was made. The number of large stone boulders (granite) on the bottom of the slab was also increased.

Rock ramp in Jedlicze after construction

Weir in Jedlicze before modernisation

Arranging of boulders weighing several tonnes

Arrangement of stones in the fish pass below the bridge

7

FISH PASS AT SZCZEPAŃCOWA

River: Jasiołka (km 27 + 960)
Fish Pass Type: Weir bypass channel
Construction Cost: PLN 1.61 million

Reason for Modernisation. The rebuilt weir was used to dam up water for the water intake. The weir consists of three sections: the two outermost sections are equipped with steel gates and the middle section is a permanent overflow. Below the overflow, a cascade consisting of three steps and ending with a stilling basin and concrete buttress was built. Below the stilling basin, a stone rapid has been created with large rocks. This weir was an insurmountable obstacle for fish.

Fish Ladder Description. The fishway takes the form of a bypass channel around the weir on the left bank of the river. It is a "bypass" imitating a natural section of the river, routed along a winding route to reduce the difference in levels and to minimize water velocity. The pools forming the fish ladder are separated by rock-strewn partitions with 30 cm wide gaps.
The fish pass was equipped with a resting pool located in the middle of the route. The exit of the fish ladder, approx. 40 m wide (on the forebay), is secured with a dumped rock riprap and sheet pile wall. Just before the outlet of the fish ladder, a wooden floating beam was installed to protect it from woody debris. The entrance to the fish ladder is at an angle of approximately 30° to the watercourse axis and is topped off with a dike made of large boulders across the entire width of the channel. The purpose of the dike is to concentrate water at low flows.

Changes Made to the Project. In June 2020, the almost ready fish pass was destroyed by the flood. The left bank between the weir abutment and the fishway outlet was washed out, the upper part of the weir was destroyed, and the remaining part was covered by gravel. It was necessary not only to repair the damage, but also to protect the fishway against similar events in the future. For this purpose, a steel sheet piling was made on the damaged shore, and a bank was armored by rip-rap.
Other minor adjustments to the design were made in the course of the project. These included a change in the method of substructure and sealing of the fish ladder bottom. The thickness of stone surcharge was increased in the bottom and slopes, a geo-grid with geo-textile and an EPDM geomembrane was used for sealing. Similarly, the rock material forming the buffles of the fish ladder was changed from granite to sandstone, as they will not be exposed to abrasion by drag debris, and the beam at the inlet made of oak was replaced with a flood-resistant coniferous timber.

Weir at Szczepańcowa before the fish ladder was built

Bypassing the weir at Szczepańcowa after completion

Arrangement of stones in the fishway

View of the damaged fish ladder after the June 2020 flood.

Monitoring the Effectiveness of Fish Passes

As a part of the project, monitoring the effectiveness of the equipment was done. It was assumed that the evaluation would be based on two different research areas: indirect and direct research. Indirect surveys focused on the hydraulic features of the fish ladders - the velocity of water flow in the gaps was examined in terms of the ability of fish to overcome them. The second area involved direct research (i.e., biological monitoring). This consisted of monitoring if fish were able to pass the fish ladders, species present, time, etc.

Flow velocity measurements at Szczepańcowa

Flow velocity measurements in Ropica Polska

Hydraulic Monitoring

Flow velocity measurements were taken in the gaps of each fishway. Flow velocity is a key assessment parameter of the fish ladder. It was assumed that all fish species living in the river should pass the fishway. The swimming abilities of fish are different, therefore the maximum water velocity at the fish ladder should not exceed 2 m/s for salmonids (salmon, trout, trout, steelhead, grayling), 1.5 m/s for cyprinids (asp, ide, barbel, ide, chub, mumps), and 1 m/s for other species (including small and juvenile fish).

Hydraulic monitoring was carried out on an ongoing basis during the construction of the fish ladders. If permissible velocities were exceeded, the project was adjusted. Such a situation occurred during the construction of the fish ramp in Ropica Polska.

Measurements of velocity and water flow were taken with a handheld Acoustic Doppler Velocimeter Flow-Tracker. Measurements in vertical profiles were made both at the inlet and outlet part of the slot.

Biological Monitoring

The starting point for biological monitoring was the definition of the so-called "Zero status", that is the species structure of fish before the start of construction. The fish were caught at all seven sites in Wisłoka, Jasiołka, and Ropa, intended for reconstruction on August 1–10 in 2019. Fishing was carried out below and above each dam, and, in special cases, those also caught in a fish ladder. The study of ichthyofauna was performed with the use of the electrofishing method (wading technique). The total length of the fish were measured.

Electrofishing downstream in Dębica

Electrofishing downstream in Mokrzec

Electrofishing downstream in Jedlicze

Measuring fish caught in Gorlice (center) below weir

Research methodology

The biological monitoring was to provide an answer to the question: "Do fish pass through the fish ladders?"

In particular:

- ≈ What is the ratio of the number of fish for a given species crossing the obstacle to all the fish attempting to cross the obstacle? (percentage)
- ≈ What delays occur, if any (i.e., how long does it take to pass the obstacle)? (hours, days).

The following assumptions were made:

- ≈ Use more than one test method for each fishway to increase reliability
- ≈ The research should be carried out in the periods adjusted to the phenological calendar of spawning and feeding migrations, according to the fish species present in the Wisłoka River (spring and autumn).

The following research methods were implemented and used effectively within the project:

- ≈ Acoustic telemetry, Vemco hydrophones, and transmitters (180 kHz) were used
- ≈ Radio telemetry using passive methods (Oregon RFID receivers and transmitters)
- ≈ Non-invasive, visual techniques such as scanners and net traps.

Hydrophone recorder

Set of acoustic transmitters for fish tagging

Rafting the Ropa River in search of fish with a mobile hydrophone

A mobile hydrophone

Kit of tools for implanting transmitters into fish

Suturing the wound of a temporarily dormant fish

Tagging Fish with Acoustic Transmitters and the Use of Acoustic Telemetry

This method consists of implanting fish with a Vemco acoustic transmitter using an individual code. The implant sends out a signal which is recorded by hydrophones anchored in the river a few hundred metres above and below the fish ladder. If a fish comes within about 100 m of the receiver, its code and time is recorded. After a few months, when the implant batteries stop working, the hydrophones are brought out of the water and the records are read. Marked fish were also searched for actively, while rafting, using a mobile hydrophone. A total of 43 km of river was checked in this way. The minimum survey sample size for a single fish ladder was 30 fish. The method was applied on the Ropa river (at the fish ladder in Ropica Polska and both in Gorlice).

Zander with floy tag

The method of tagging fish with implants is invasive. For this reason, great importance was attached to safety during performance - sterility of tools and painlessness of the "procedure". Each wound was sutured, protected with special tissue glue, and disinfected. Fish were temporarily put to sleep for the duration of the procedure.

Passive Implantable Fish Tagging (PIT)

The tags are implanted in the fish using a special syringe. The activity of these tags is triggered by an antenna used to detect the tagged fish. The antennae can be laid flat on the riverbed or vertically in the gaps of the fish ladder in the form of a window through which the tagged fish pass. This method requires special conditions, including availability of installation sites in the river and optimum positioning and placement of antennas, surveillance during surveys, suitable hydrological conditions, and weather conditions. For a single fishway, more than 200 fish were tagged. This method was used at the fish ladders in Szczepańcowa, Gorlice at the waterworks and in Mokrzec.

Another passive method is plastic tags with a printed telephone number implanted under the dorsal fin. However, this method gives information on only 1–2% of the tagged fish, as its effectiveness depends on the fish being caught and the angler calling the number. For this reason, it is used to obtain information on fish migration directions. It was used to mark fish caught in Gorlice (centre) before the fish ladder construction started.

Placing an implant

Observation of Fish Migration Using an Automatic Counter

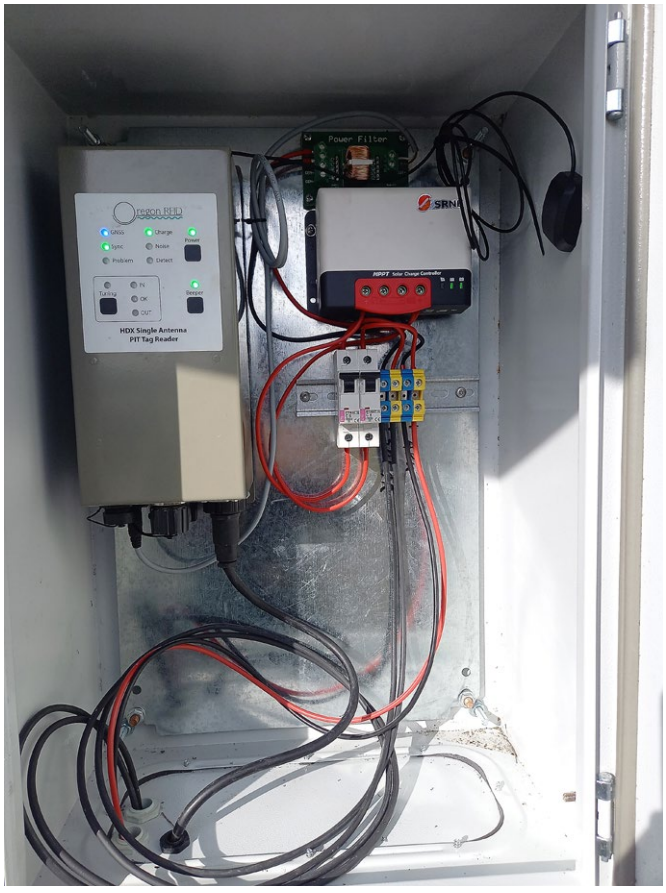
Automatic fish movement counters allow the non-invasive observation of fish migration. Motion sensors allow fish to be counted and allow a more nuanced assessment of the fishway functionality, including distinguishing the direction of migration. However, this method has the disadvantage that it does not distinguish between fish that pass through the fishway repeatedly and thus overestimates the results. Such a scanner has been installed on the fish ladder in Mokrzec and Dębica. A Vaki scanner with Winari specialist software was used.

Trapnet Fishing

This method was used to obtain data on fish crossing the structure and moving upstream. Fyke nets (i.e., traps made of 12 mm mesh netting placed at the upstream exit of the fish ladders) were used to catch fish moving upstream. The total trap exposure time at the fishway was typically 3 days and was sufficient to confirm migration. This method was used at the fish ladder in Szczepańcowa and in Jasło.

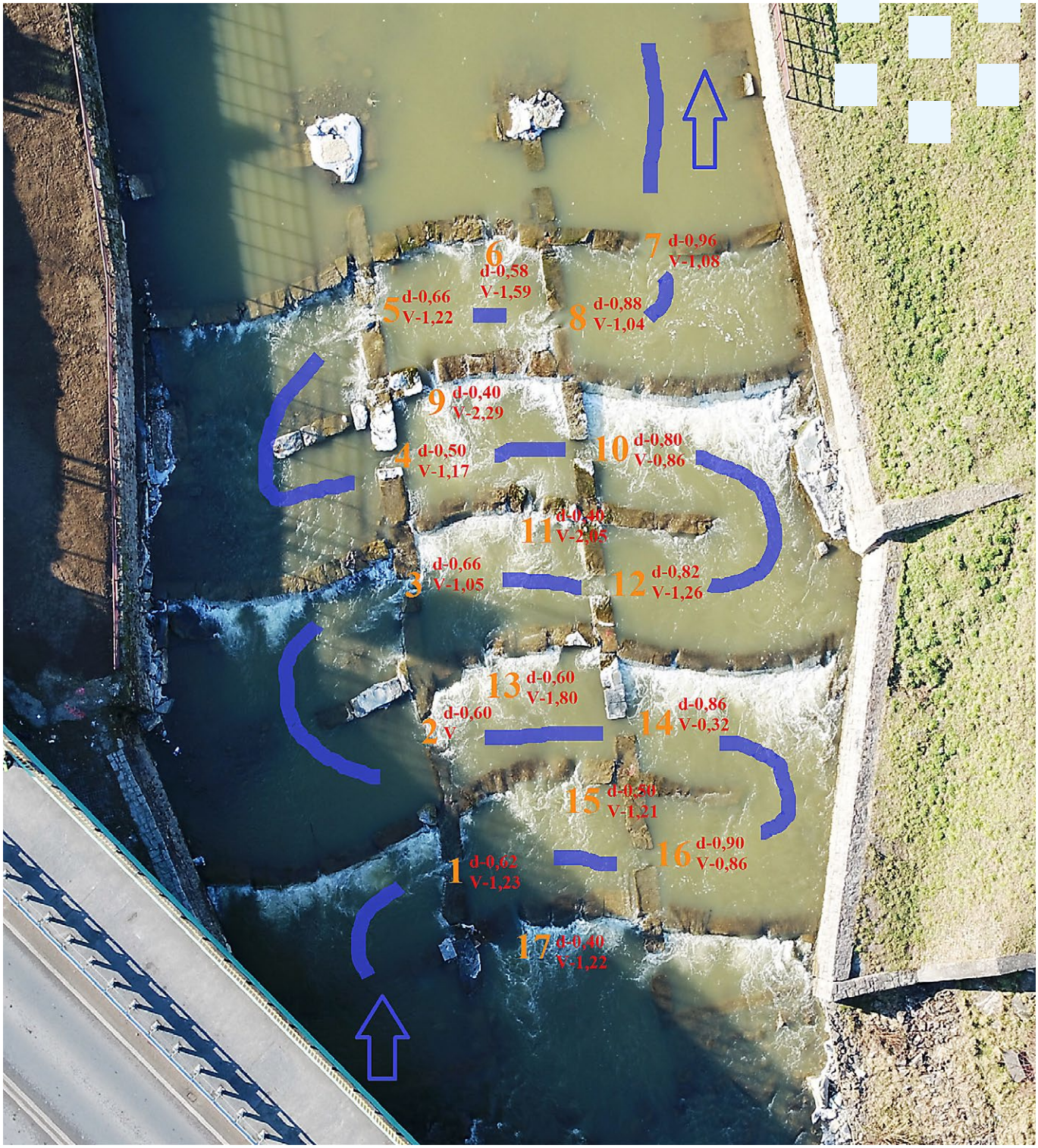
Installation of a scanner at the technical fish pass in Dębica

Fish trap to monitor upstream migration of fishes



Electronics recording PIT tags implanted in fishes

Vaki system scanner recorder (computer)



Results of water velocity measurements in the slots and the designed fish migration route in the Gorlice fish ladder (center)

RESULTS OF MONITORING THE EFFECTIVENESS OF THE FISHWAYS

Results of Hydraulic Monitoring

Water velocities in the slots of the fish ladder were 80% between 0.6 m/s and 1.2 m/s, in 15% they were higher at 1.2 m/s to 1.7 m/s, and in single slots were 1.8 m/s to 1.9 m/s. In a few cases, these high velocities were caused by clogging of the gaps near the bottom. After cleaning, the velocities decreased. The picture shows an example of the analysis of measurement results.

Monkey goby

Carpathian barbel

Vimba

European bullhead

Ruffe

Ide

Kessler›s gudgeon

Gudgeon

Tench

Spirlin

Common nase

Rudd

Biological monitoring results

"Zero state" assessment

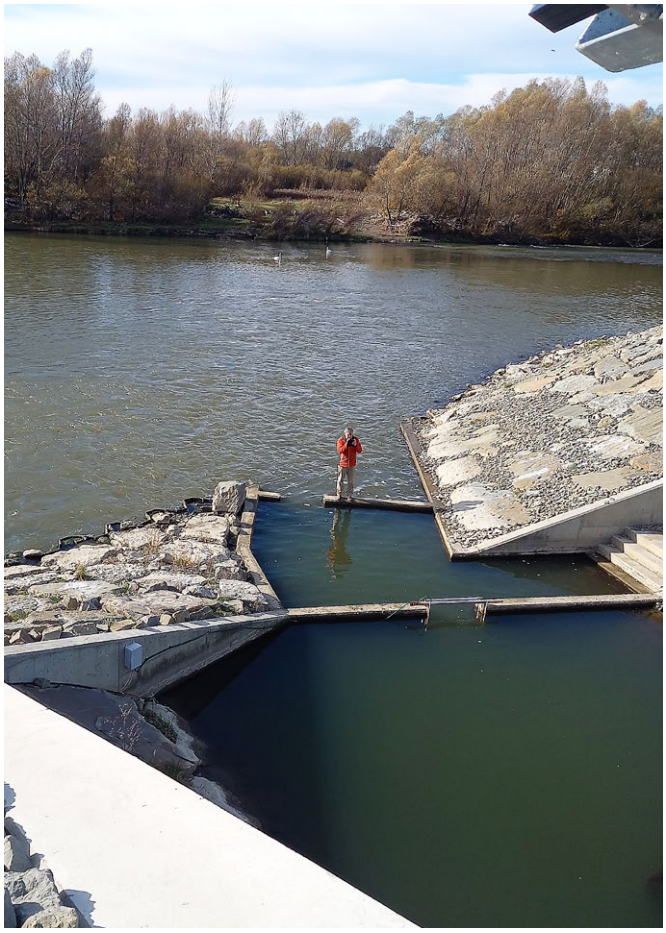
In total, 30 species of fish were found in Wisłoka, Ropa, and Jasiołka Rivers, including (in alphabetical order): barbel, brown trout, Carpathian barbell, catfish , chub, common bream, common dace, common nase, common bleak, eel, european bullhead, eurasian ruffe, goldfish, gudgeon, ide, Kessler's gudgeon, monkey goby, minnow, perch, Prussian carp, rainbow trout, roach, rudd, spirlin, stone loach, tench, white-finned gudgeon, white bream, and zander.

The highest number of species occurred below the weir in Szczepańowa (12 species), the lowest in the backwater above the weirs in Dębica and Gorlice (center) had 3 species. In general, it was found that there were drastically fewer fish above each weir. The average length of fish in the rivers of the Wisłoka catchment was also determined to be 10 cm to 18 cm, depending on the size of the river. The most frequent fish species were stone loach, chub, Carpathian barbel, perch, spirlin, common nase, gudgeon and bleak.

Assessment of Fish Migration Using Different Methods

In accordance with the recommendations and methodology, surveys were carried out using various methods and at times adapted to the phenological calendar of spawning and feeding migration of fish species that occur in the Wisłoka catchment area. The results of monitoring confirmed that all fish ladders have fulfilled their task - fish can again migrate in both directions. Below are the detailed results.

Fish pass in Dębica. Monitoring was performed using two observation techniques: the Vaki automatic scanner and the Vemco acoustic transmitters. The Vaki scanner mounted at the Dębica fish ladder operated for 38 days. During the whole research cycle, 461 fish moved up the fishway and 123 fish moved down the river, were recorded. At the same time monitoring using the Vemco acoustic tag method was applied at the site. The transmitters were used to tag 20 fish of four species: chub, brown trout, nase, and grayling. The recorders, so-called hydrophones, were in the river for 27 days and, during this time, the upper hydrophone recorded the passage of 9 fish through the fish ladder. The pas-



The antenna installed at the entrance to the fish ladder in Mokrzec (downstream)

Trout recorded by the scanner in Mokrzec

Interior of the observation chamber in the monitoring building at the fish ladder in Mokrzec

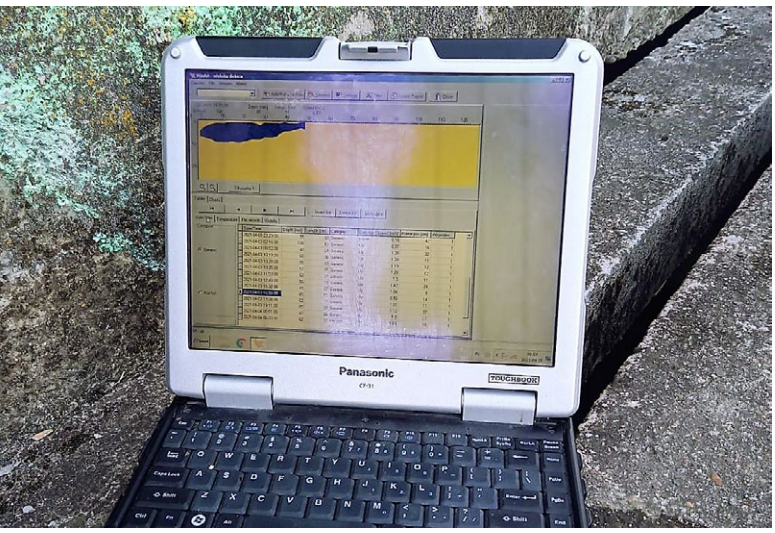
Duck mussel (Anodonta anatina) inhabiting the fish pass in Mokrzec

Fish caught under monitoring in a fish pass in Mokrzec

sage time counted from the moment the tagged fish were released and ranged from 3 hours and 40 minutes (37 cm chub) to 47 hours (42 cm nase). The remaining fish stayed below the fishway during the study period and were recorded by the lower hydrophone.

Fish pass in Mokrzec. Monitoring was also performed using two observation techniques: Vaki automatic scanner and Oregon RFID passive transmitters. Three hours after installing the scanner and filling the fish ladder with water, the first chub appeared in the Mokrzec reservoir. The fish ladder proved to be the habitat of choice for 21 species of fish and 3 species of bivalve mollusks from the unionids family (Anodonta natine, Unio tumidus, and U. pictorum).

Fish pass in Ropica Polska, Gorlice-Centrum and Gorlice-Waterworks. Due to the short distance between the fish ladders, the monitoring was carried out together and at the same time. Vemco's acoustic tagging method was used. A total of 50 fish of four species: chub, brown trout, nase, and grayling were caught and tagged from the river. The tagged fish were released into the Ropa River at various



Reading the measurement results with a scanner in Dębica

Antenna installed in the fish pass in Gorlice (water intake)

Migration recorder with the use of PIT tags at Szczepańcowa

Handheld signal reader and unique code from an implant implanted in fish

places below the fish ladders. Signals from their transmitters were recorded by three receivers mounted above the fish ladders. In order to increase the effectiveness of monitoring, an additional several days' rafting with a mobile hydrophone was carried out to find the tagged fish that may have migrated far from the fish ladders. Approximately 16 km of the river were monitored daily, with a total of as much as 43 km of the river. Data collected by the equipment showed that 22 fish passed the fish ladder in Gorlice-centre, and 20 fish passed the fish ladder at Gorlice-waterworks. The receiver in Ropica Polska recorded 7 fish, of which the first passes took place after 24 hours. However, these results are underestimated because during the measurement period, an unknown person removed the hydrophone from the river, thus interrupting the measurement cycle.

In autumn 2020, a technique using PIT tags was tested on a previously surveyed fish ladder in Gorlice at the waterworks. Antenna design, power system, and reading technique were tested. A total of 37 fish of different sizes were caught, tagged, and released into the Ropa below the fish ladder. The results collected from the antennas confirmed the possibility of migration through the fish ladder.

Fish pass in Jedlicze. Monitoring was performed using Vemco acoustic transmitters. The transmitters were used to tag 30 brown trout, which were released into the Jasiolka River below the fish ladder. In order to detect the signals from the acoustic transmitters, two passive VR2W receivers from Vemco were installed, one above and one below the fish ladder. Hydrophones recorded and confirmed the passage of 16 fish. In the case of 10 trout, migration through the fishway was confirmed within one day, the others within the following 4 days.

Fish pass at Szczepańcowa. Monitoring was performed using passive OREGON RFID transmitters. Two receivers, so-called recorders, were installed in the study area at the entrance and exit of the fish ladder. A total of 125 fish were caught and tagged in the bypass area. Due to the passage of a flood wave, recording was carried out for only 5 days. During this time, the upper recorder, located behind the inlet channel to the fish ladder from the upper water, recorded a total of 13 fish (12 chub and 1 mump). The first 4 chubs crossed the fishway after about 9 hours from the tag implantation.

Environmental Supervision of Measurement Implementation

The environmental supervision activities focused on monitoring the construction in terms of their compliance with the provisions of the environmental decision and provisions on the protection of species and natural habitats.

As part of the supervision, a schedule for construction was in agreement with the project manager, taking into account environmental requirements. Ongoing monitoring of the construction process was also carried out to prevent any potential damage to the natural environment. Among other things, care was taken to ensure that the manner in which construction work was carried out did not cause water turbidity or pose a threat to fish and aquatic organisms. Appropriate methods for preventing water turbidity were recommended, including various techniques for separating the construction area from the current so that the work can be carried out "dry". The photos show examples of the methods used - fencing off with sandbags (big bags), Larsen walls, and running the access road to the construction site on steel pipes to allow water to flow.

As part of nature supervision, fish that settled in the river below the Gorlice barrage (centre) before construction started were also caught and transferred to the completed fish ladder in Ropica Polska - some of the fish were marked with PIT tags. Anglers from the PZW District in Nowy Sącz aided in catchment.

Protection against siltation by big bag in Jedlicze

Protection against muddling in Gorlice (center)

Release of caught and measured fish to the fish pass in Ropica Polska

Intervention catching fish in Gorlice

Information and Promotion Activities

Projects co-financed by the European Union require communication activities. In this case it was particularly important, largely because the investments involved in the project are being undertaken for the first time in Poland on such a large scale. Their importance cannot be overestimated, and their experience should be used in other projects.

Project website

As part of information activities, a project website was prepared containing not only its description - objectives, tasks, investments, but also additional information and interesting facts. We tried to prepare interesting texts on the subject of the project and short interviews with people involved in its implementation. More than 30 such texts were prepared. A fan page was also run, with more than 60 posts.
As a part of the promotion, an information brochure on the project was developed and a note was sent to the media, followed by several publications. The project was promoted at two international conferences. In Turkey, at the 3rd cyclical conference related to the Black Sea region entitled "Balancing Agriculture and Environment" organised by Gaziosmanpasa University in Tokat, and at the session of the Polish-Slovak Water University entitled "People, Water, Climate, Landscape". "People, Water, Climate, Landscape, Future" organized by European Territorial Cooperation Group TRITIA together with Oz Chováme doma Civic Association (online lectures). Additionally, it was also presented at several national meetings, including a training for tourist guides and an online meeting with anglers. One of the major events for the project was a webinar conducted on World Fish Migration Day, which was reported as one of the Polish contributions to this international celebration.
We invite you to read the materials on the website www.wislokabezbarier.com and on the Wisloka-bez-barier Facebook page.

Promotion of the project during the training of tourist guides in Ciężkowice

Information board at the fish ladder in Mokrzec

Studio webinar on the occasion of World Fish Migration Day

Lesson Learned from Project Experience

Each fishway, if technically possible, should be checked for functionality already during construction. Flow velocities in the gaps should be continuously measured and compared with the design assumptions. If the velocities are too high, corrective measures should be taken to reduce them. This should be a permanent element of the investment process.

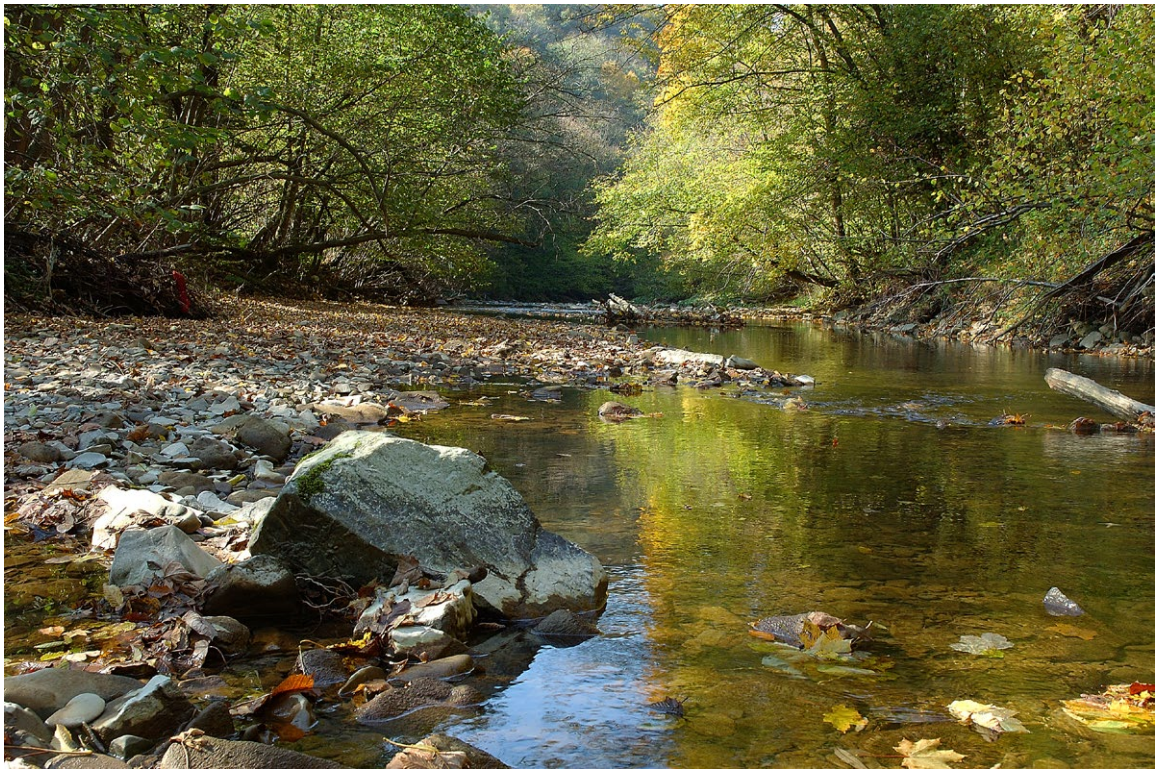
The fish ladder should be designed and constructed with the key assumption of its migratory efficiency for all fish inhabiting the river. The swimming abilities of fish depend not only on the species but also on the size of fish, so the parameters of the fish ladder should enable it to be passed by both salmonid fish and weaker swimmers - fish migrating over shorter distances, and fish at different stages of development, including juveniles.

In addition to checking hydraulic parameters, such as velocity distribution and turbulence, it is essential to check whether fish actually pass the constructed fishway. There are many techniques of conducting such tests. It is necessary to choose the one which is feasible and gives reliable and statistically indisputable research results. In practice, net traps, radio tags, acoustic tags, PIT-tags, and scanners work well.

All fish passes require periodic cleaning. The frequency of such operations depends on the type of fishway. The biggest problem is posed by fish ladders located outside the riverbed (i.e., bypasses in the form of cascades, pool passes, and also fish ladders of the rock ramp type on a part of the riverbed). The closer the fishway is to the natural river, the less influence it has blocking the individual gaps and proper functioning.

Periodic monitoring of the fishway condition by the water administrator may be insufficient to maintain its permeability, therefore it is worth establishing a cooperation with fishery users (anglers and fish farms) and the dam user on which the fishway has been built. This cooperation can effectively relieve the water administrator from time-consuming supervision of the facility and will often make it possible to transfer the duty of ongoing maintenance (e.i., removal of debris and blockages) to the stage owner.

Graylings



Jasiołka River

The Wisłoka River and its tributaries were historically a habitat that has been impacted by weirs and regulation work which led to the disappearance of environments necessary for spawning, incubation of eggs, rearing of fry, feeding grounds and wintering grounds of adults. This has resulted in the extinction of sturgeon, salmon, sea trout, and vimba from this area. The populations of other river fish species (single habitat) were severely depleted as well.

In addition, ichthyofaunal studies carried out in recent years in the upper Wisłoka, Jasiołka, and Ropa river basins indicated high species diversity in adjacent, but separated by partitions, sections of the river. For this reason it became necessary to liquidate or modernise the water stages in such a way that they would not constitute a barrier for aquatic organisms.

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PGW WP RZGW w Krakowie

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