A NEW CONCEPT OF FRONTAL MIGRATION SYSTEM FOR FISH – FOR OVERFLOW WEIRS AND RIVER SILLS

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ABSTRACT

In this paper we present a new frontal migration system for fish which could be used for overflow weirs and river sills. Since movement of fish is the most crucial thing in the healthy river environment fish passes are necessary to predict in any place where hydraulic structures are designed or any river engineering works are applied in the river channel. Thus in our paper we are giving a proposal of a new fish migration system when any river cross section weirs, sills or other low head hydraulic structures are planned. We hope our system would be built one day proving the advantage of using it.

RÉSUMÉ: Un nouveau concept de système de migration frontale des poissons – pour les déversoirs et les seuils des rivières.

Dans cet article, nous présentons un nouveau système de front de migration pour les poissons qui pourrait être utilisé pour les déversoirs et les seuils des rivières. Puisque le mouvement des poissons est la chose la plus cruciale dans l'environnement sain de rivière les passes de poissons sont nécessaires pour prévoir dans n'importe quel endroit où les structures hydrauliques sont conçues ou n'importe quels travaux d'ingénierie de rivière sont appliqués dans le canal de rivière. Ainsi, dans notre document, nous proposons un nouveau système de migration des poissons lorsque des barrages, des seuils ou d'autres structures hydrauliques à faible chute sont prévus. Nous espérons que notre système sera construit un jour pour démontrer l'avantage de l'utiliser.

REZUMAT: Un nou concept de sistem frontal de migrare pentru pești – pentru deversoare și praguri de râu.

În această lucrare vă prezentăm un nou sistem frontal de migrare a peștilor, care ar putea fi utilizat pentru deversoare și praguri de râu. Deoarece mișcarea peștilor este cel mai important lucru într-un mediu sănătos al râurilor, prevederea trecătorilor pentru pești este necesară în orice loc în care sunt proiectate structuri hidraulice sau orice lucrări de inginerie a râurilor aplicate în albia râului. În această lucrare oferim o propunere pentru un nou sistem pentru migrarea peștilor atunci când sunt planificate deversoare, praguri sau alte structuri hidraulice. Sperăm că sistemul nostru va fi construit într-o zi dovedind avantajul utilizării lui.

INTRODUCTION

The lotic systems suffered extremely variated modification types and degradations in the last decades all over the world due to a high number of variable factors (Curtean-Bănăduc and Farcaş, 2013; Gromova et al., 2013; Curtean-Bănăduc, 2014a, b, 2015; Barinova et al., 2016; Marić et al., 2017; Pacioglu et al., 2019; Piria et al., 2019; Barinova et al., 2020; Bănăduc D. and Curtean-Bănăduc A., 2020; Caleta M. et al., 2020; Kar and Khynriam, 2020; Kar et al., 2020; Najib et al., 2020; Radkhah and Eagderi, 2020; Radkhah et al., 2020; Schneider-Binder, 2020; Şahin et al., 2020; Valiallahi, 2020; Askeyev et al., 2021; Barinova, 2021; Barinova and Mamanazarova, 2021; Cianfaglione, 2021; Rios, 2021; Savenko and Kryvtsova, 2021) including due to the rivers engineering. River engineering is sometimes a necessity especially when the rivers or streams must be prevented against flooding, use for obtaining electric power, irrigations, etc. However any hydraulic structure built in the river channel could create ecological problems for lotic environments, including for the local or/and regional organisms, among them the one of the most important indicative for lotic systems ecological status taxonomic group, the fish, is a typical example (Voicu et al., 2014, 2020a; Popa et al., 2016; Radecki-Pawlik et al., 2019; Costea et al., 2021; Bănăduc et al., 2014, 2020, 2021). All fish species need a continuous free access to different habitats (feeding, sheltering, wintering, spawning, nursery, etc.) all along their life cycle. The occurrence of habitats fragmentation and degradation is significantly opposing them to reach the fish population optimum distribution and ecologic status, or even make them to vanish. Such fragmentations can be created including by all types of damming structures which need the best in situ adapted type of overflow weirs and river sills to be used in each specific case. That is why the enrichment with new concepts of these constructions global portfolio is not only a necessity but a must (Bylak et al., 2017).

The Water Framework Directive (Directive 2000/60/WE) was introduced to help conserve river geomorphical and ecological integrity across Europe. This Directive emphases on ensuring (or re-installing) the natural hydromorphic functioning of watercourses and helped set the challenge of finding new solutions to the long-standing problems caused by river engineering (Plesiński et al., 2021). This challenge requires multidisciplinary integrated researcher teams to bring into light new innovative concepts including for avoiding or repairing lotic systems fragmentation and degradation.

There are many impact types on fish habitats of barriers which block, disrupt or/and delay movements, inducing reduced fish fitness, ecological status and increase their mortality. In order to allow the fish to overpass abrupt level differences on rivers resulting from artificial damming by dams, weirs, drops, sills and other engineering structures, and also natural barrages formed by waterfalls, hydraulic technical structures called fish passes or fish ways, are or should be carefully built. There are relative numerous designs of such structures for fish spatial mobility and even migration: conventional pool passes, slot pool passes, denil (baffle) fish passes, modular meander-type fish passes, cascaded pool fish pass with boulder weirs – step-pool rock ramp fish way, ramp riffles, cascades, cascaded bypasses, bypass in the form of riffles, fish lifts, ropeways and railways, etc. (Tymiński and Kałuża, 2013; Mokwa and Tymiński, 2017).

Fish ladders and passages were found to be the most common means of passing fish upstream man made barriers (Čada and Jones, 1993). The design of a fish pass is one of the most challenging processes in water engineering, due to the technical problems to be solved in the conditions of the in situ environment related needed adaptations. This is because the designer is faced here with a problem that requires solving several interrelated tasks: the design work, the hydraulics of liquid and solid flow and the biological and ecological characteristics of the local and regional fish species. Therefore, the best solution would be the cooperation of hydrotechnical engineers and technicians with biologists and ecologists with expertise in aquatic ecology and ichthyology in the design, construction, and monitoring of these special created and adapted technical structures. The most common problems occurring during the operation of the fish pass are the lack of attracting current for fish at the exit of the fish pass (connections of the fish pass with the river bed), lack of monitoring (e.g. dislodging after extreme events), no positive reaction to changing natural and/or human induced hydrological conditions, and last but not least poaching (Bănăduc and Curtean-Bănăduc, 2019; Bartnik et al., 2010; Plesiński et al., 2020; Bănăduc et al., 2021).

When designing a fish pass, it is important to combine good engineering practice, good biological and ecological assessment and monitoring data, careful laboratory tests, and numerical simulations (Teppel and Tymiński, 2013).

Also an important aspect in the restoration of longitudinal connectivity in rivers and streams is the implementation of fish migration systems at the upstream of the functional hydraulic structures (weirs, drop structures, or river sills). The diversity of these existing structures as well as the different locations of these weirs within the lotic system, riparian zone, and watershed challenges the design engineers to find new holistic adaptative solutions for fish migration systems (Voicu et al., 2020b).

Thus in this work we present one of the fish-like pass systems which we call frontal fish migration system. It can be built for overflow weirs and sills and used in any hydraulic river engineering works. We hope our system will be built one day and prove its usefulness.

DESCRIPTION OF MIGRATION SYSTEM

Before making a ridge (migration channel) on approximately the entire length of the overflow weir, it will be increased in width by adding a layer of concrete both upstream and downstream of approximately 10 cm (Fig. 1).

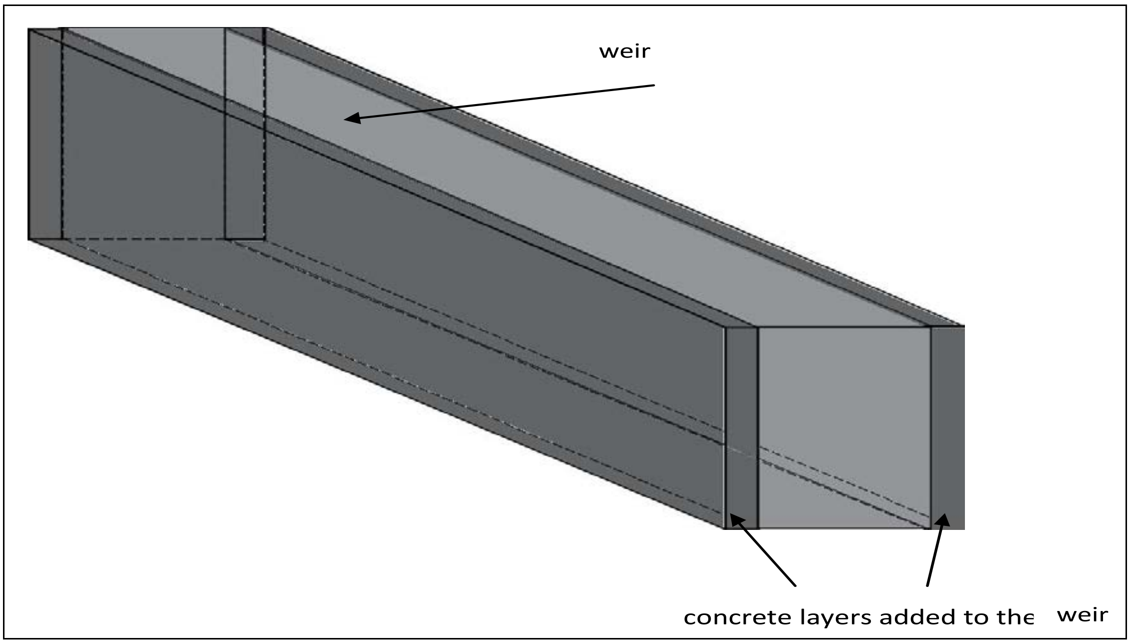

Figure 1: Positioning the concrete layers on the weir.

After the overflow weir has been lined with concrete on either side like it is shown in figure 1, a crenel is drilled perpendicular to it. Before approximately 10 cm to pierce the spillway weir, the battlement (crenel) will bend to the left or right depending on how the end of the crenel is positioned. In this case, the battlement (crenel) turns to the right (Fig. 2).

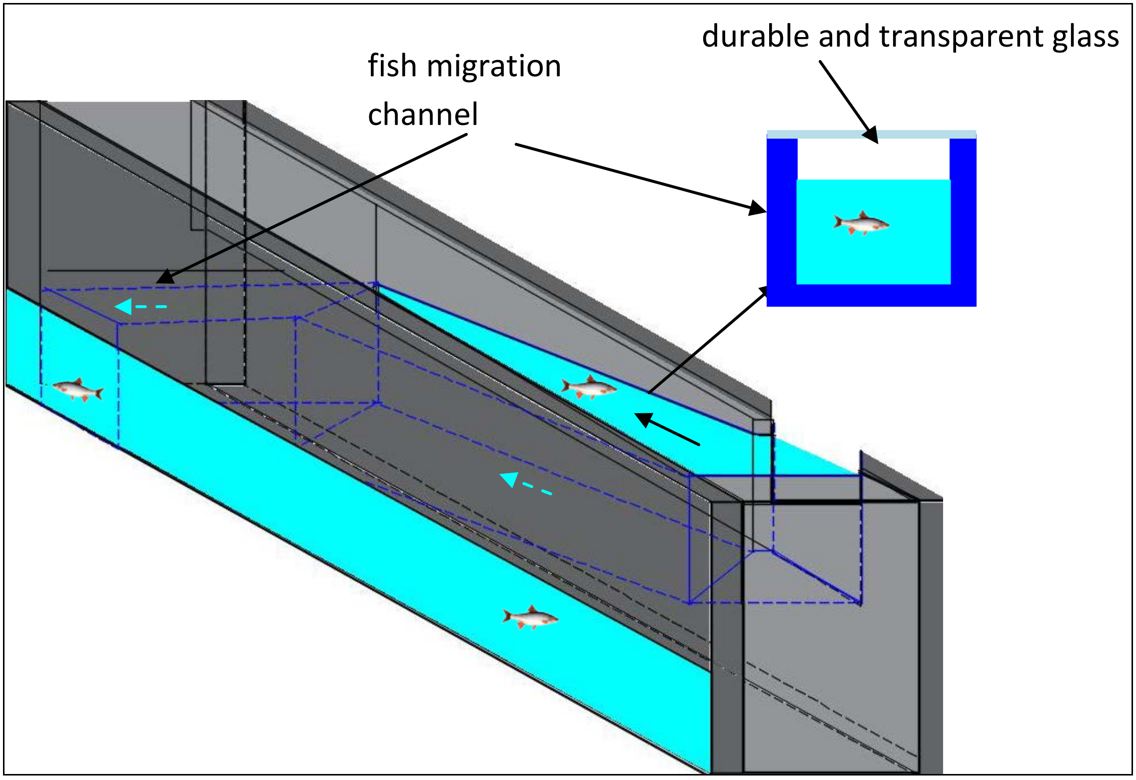

Figure 2: Positioning the battlement inside the weir.

After the battlement turns to the left or right, its slope will be chosen according to the biological and ecological characteristics migratory species in the river or stream of interest. The whole fish migration channel is covered by a resistant and transparent glass sheet (Fig. 2). Over this glass sheet, the stream will pass or not. But it will still protect the fish's migration channel so that water does not enter it. Being transparent glass, the fish will have enough light to be able to migrate. After the channel for migrating the fish has passed a portion of the weir (through it) it will turn left or right (Fig. 2). If the downstream end of the migration channel is below the water level by about two thirds then the end of the channel will not be extended (Fig. 2). If the downstream end of the fish migration channel is above the river water level, the channel will extend with the same slope outside the weir so as to reach the watercourse (Fig. 3).

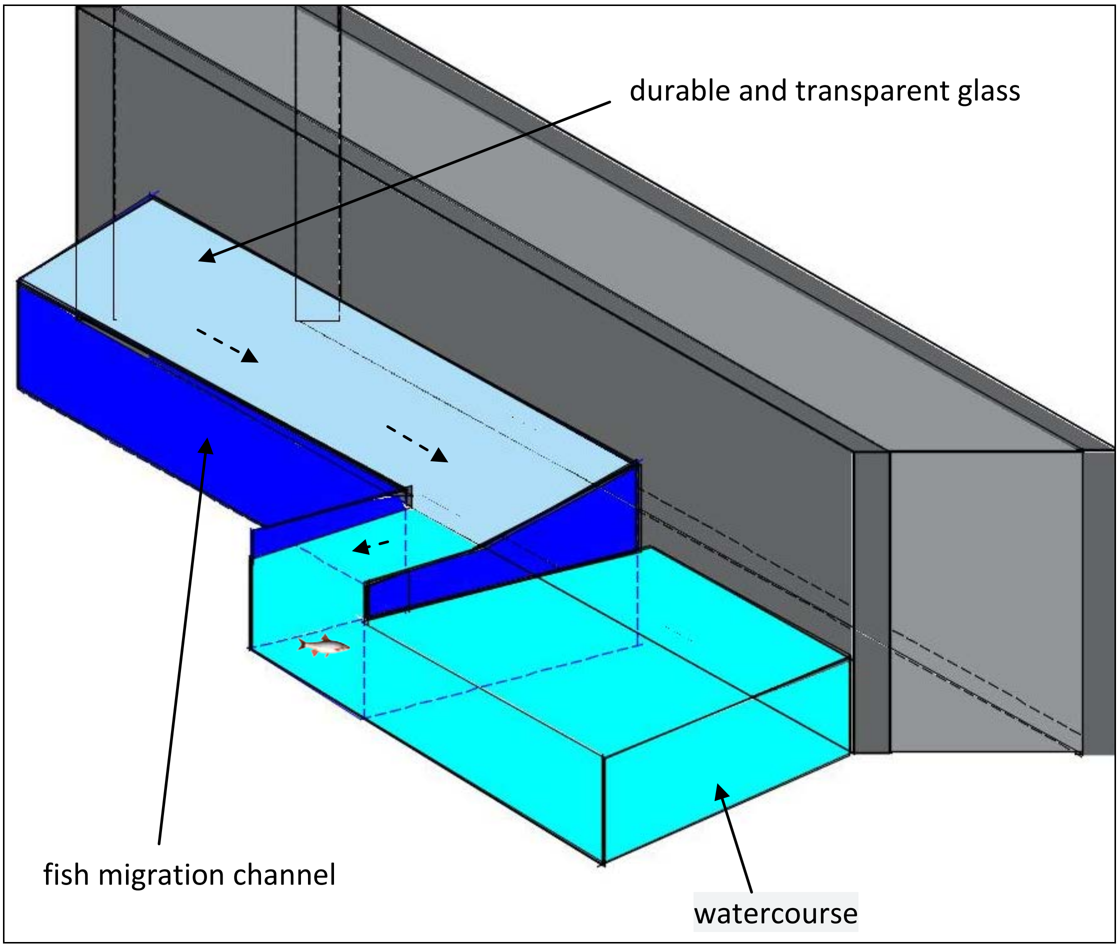

Figure 3: Extension of the canal to the watercourse.

The shape of the channel fixed to the weir will have a trapezoidal shape closing in the upper part with a resistant and transparent glass ceiling (Fig. 3). If the downstream end of the fish migration channel even in these conditions will not reach the watercourse then the downstream end will be connected to a basin, to two basins, three connection basins that have a direct connection with the river (Fig. 4).

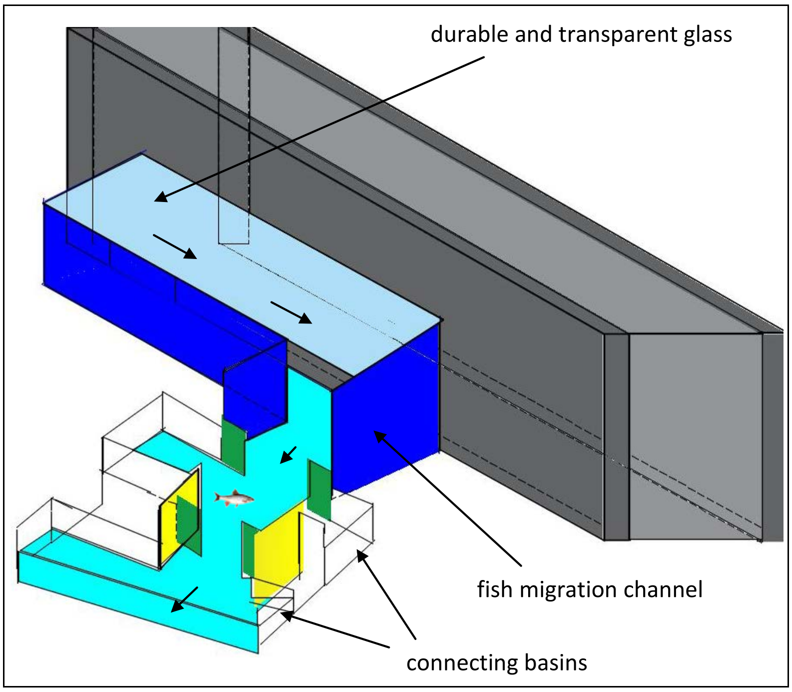

Figure 4: Positioning of connecting basins.

The system is functional at overflow thresholds of heights less than or equal to 2.5 m.

The advantage of this technical system is that during floods it can hardly be damaged. A semicircular metal bar fixed at the top will protect the channel from floats (Fig. 5).

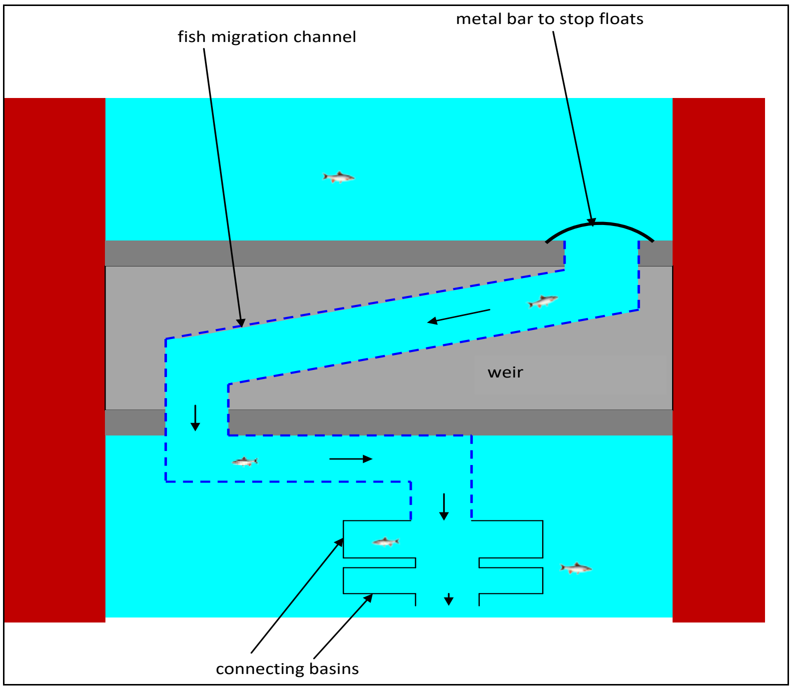

Figure 5: General scheme of the system for fish migration.

CONCLUSIONS

Fish ladders should be an integral part of weirs and dams, especially those that block the migration path for fish. Unfortunately, it is too often possible to find hydrotechnical structures in the riverbeds without elements supporting the migration of fish. Therefore, such facilities should be modernized and new ones should be constructed with fish passes.

The system proposed here has several advantages: relatively low cost of creation; taking up a small space (no influence on the external structure of the overflow threshold); protection against poaching (difficult access for outsiders); low costs of monitoring and operation; no impact of flood waters on the migration system; production of attracting current.

An additional advantage of the discussed system built of local and natural materials (stones, boulders – increasing the roughness of the surface of the walls and the bottom of the system elements, as well as imitating the natural conditions of the river bed bottom), macrozoobenthos will be able to be present in the system, and probably also migrate.

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