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PRINCIPLE AND DESIGN OF HATCH OPERATION SYSTEM FOR FISH MIGRATING UPSTREAM--DOWNSTREAM OF THE DISCHARGE SILL

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Abstract. To improve fish migration and restore local lotic ecosystems, it is necessary to consider the various current hydro-construction methods. There have been partial successes in systems that improve fish passage over various obstacles but new approaches that present more efficient solutions and international collaboration among specialists are required.

This article deals with European themes of great interest; issues related to interruption of longitudinal connectivity in heavily modified water courses, and improving the ecological status of damaged lotic systems, with the goal of achieving the environmental objectives set forth by the Water Framework Directive 2000/60/EC (WFD) and the national legislative framework regarding water policy (which reflects the European directives) Water Law no. 107, with subsequent amendments, NT No. / 2006 OM 1163/2007, and discusses the obligation to ensure that construction works protect fish migration to maintain ecological balance in the reservoirs. It is possible to use this system in almost any fish-bearing stream, both upstream and downstream of maximum circulation, which makes the system an excellent solution for assisting and improving migration.

Key words: longitudinal connectivity, fish migration, dam, water course, fish passages

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INTRODUCTION

Fish passage is an important design consideration for dams around the world and many dams are now being retrofitted to facilitate upstream movement of ichthyofauna over the structures. The success of fish passage systems is variable [Bunt et al. 2012], suggesting a need for continued work in designing and testing new systems. Although the impacts of dams on geomorphology and thermal regimes will remain, fish passage systems can provide some relief for migratory fish species in cases where dam removal is not an option. The subject of this article represents a European theme of great topicality and interest; the restoration of the water courses affected by hydromorphological pressures created by the presence of transversal works which lead to the interruption of longitudinal connectivity in rivers, halting fish migration and modifying the flow regime [Kay and Voicu 2013]. The need for longitudinal connectivity of watercourses is an essential condition of the Water Framework Directive approved by the European community and therefore it should be applied to all streams containing migratory species [Voicu and Merten 2014]. Activities such as dam construction for water supply and power generation, channelization for navigation and flood control, land drainage and wetland reclamation for agricultural and urban use, all have a profound impact on the aquatic ecosystem and thus on the natural fish populations. One of most damaging effects of dams and weirs is the interruption of the longitudinal connectivity of the river which means that fish cannot migrate freely anymore. This not only concerns long-distance migratory species but all fish that depend on longitudinal movements during certain phases of their life cycle. Fish passes are of increasing importance for the restoration of free passage for fish and other aquatic species in rivers. Such devices are often the only way to make it possible for aquatic fauna to overcome obstacles that block their up-river journey. They then become key elements for the ecological improvement of running waters [Fish passes… 2002]. Biology, geomorphology, hydrology, water quality and connectivity are components that work collectively to define rivers and their health. Each of these components is, in itself, a complex group of variables. Changes in one of these components can have a cascading effect on the other components [Aadland 2010].

Fish passes (for both upstream and downstream migratory fish) must be designed so that the fish are able to find the entrance to the system provided for their passage and swim through without undue effort and unusual risk of injury. One of the most important parts of fish passes is a fish pass pool (chamber). When poorly or wrongly designed, fish flowing through the fish pass cannot find a proper way up the fish pass structure or a place for a rest in fish pass pools. Thus, in the present paper, one of the fish pass construction methods was examined in the context of the optimal shape designed as far as distribution of water velocity, shear stresses in fish pass pools and the position of it in relation to a check dam weir are concerned [Radecki-Pawlik 2003]. Fish migrations evolved as adaptations for more efficient utilisation of resources irregularly distributed in space [Lucas and Baras 2001]. Habitat differentiation between connected water bodies requires fish to move between different habitats along with the changing needs during ontogeny. Eggs and young fish that are vulnerable to low dissolved oxygen levels can develop in well-oxygenated mountain brooks and then as they grow, move towards areas offering more abundant food and space lower down the course of rivers and/or the sea [Kruk 2004].

There have been many methods and inventions as specialists have tried to find solutions to facilitate the migratory fish passage over transversal obstacles (dams, discharge sills, etc) as these transversal obstacles block the passage of numerous migratory fish species in many countries. The proposed solution here is based on some theoretical principles and also provides a viable alternative to the older methods used (bypass, fish ladder, hatch, fish passage, natural bypass channels, fish elevators / lifts etc).

MATERIALS AND METHODS

Upstream of the discharge sill, at about 1 m distance, a vertical concrete rectangular parallelepiped 1 is installed (Fig. 1).

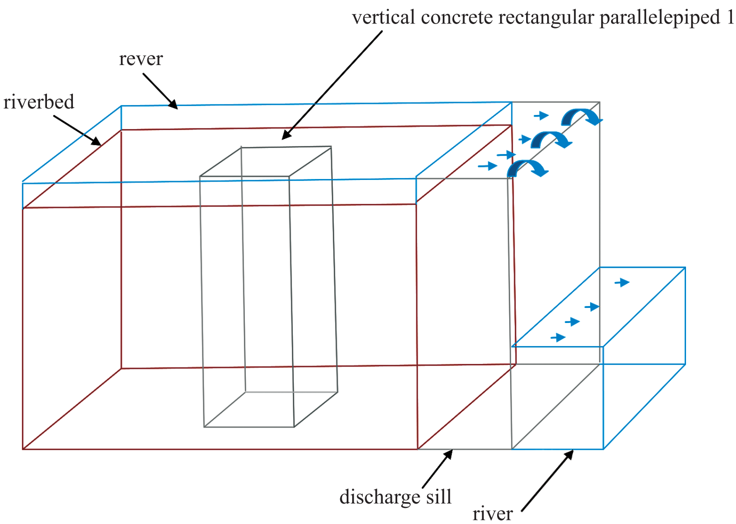

Fig. 1. Positioning the vertical concrete rectangular parallelepiped 1 – indicative scheme

Inside the vertical concrete rectangular parallelepiped 1, four supportive and guiding metal rails are affixed (Fig. 2).

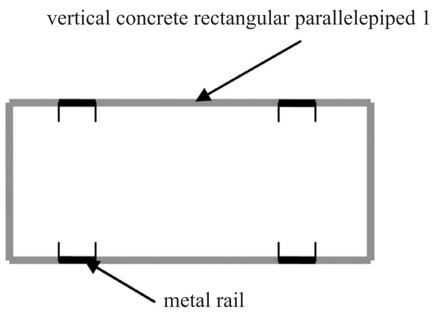

Fig. 2. Positioning the rails inside the vertical concrete rectangular parallelepiped 1 – indicative scheme vertical concret

The rails are made of stainless steel. A stone parallelepiped is affixed by spacers and resistant rubber surfaces to the metal rails (Fig. 3).

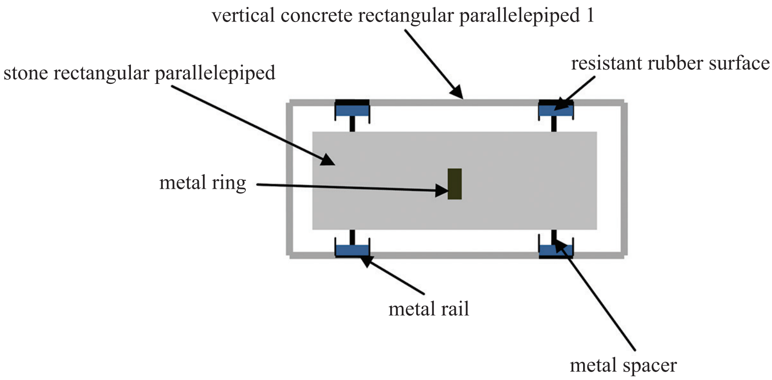

Fig. 3. Fixing the rectangular stone parallelepiped to the metal rails – indicative scheme

Metal railings are the same length as the vertical concrete rectangular parallelepiped 1. Near the vertical concrete rectangular parallelepiped 1, a concrete foundation is installed and a winch is connected (Fig. 4).

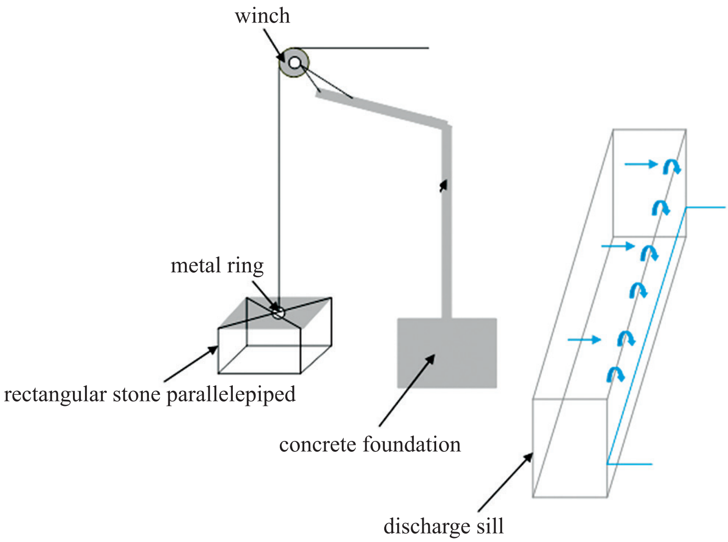

Fig. 4. Positioning the concrete pile located upstream of the discharge sill – indicative scheme

Downstream of the discharge sill, another vertical concrete rectangular parallelepiped 2, larger than the first one, is built at a distance that can vary between 1 and 3 meters in the bed of the watercourse. It will be tightly covered by the middle folding sheet pile (Fig. 5).

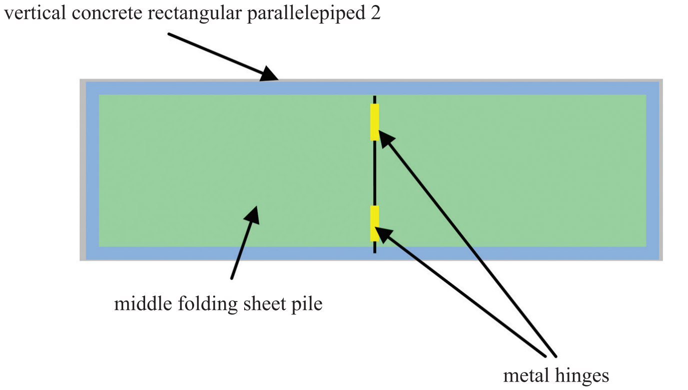

Fig. 5. Positioning the middle folding sheet pile – indicative scheme

At the base of the vertical concrete rectangular parallelepiped 2, a circular canal made of concrete ducts is built (Fig. 6). It has dimensions that may vary between 10 and 100 cm depending on the local conditions; it is built on slope to facilitate the flow of water gravity.

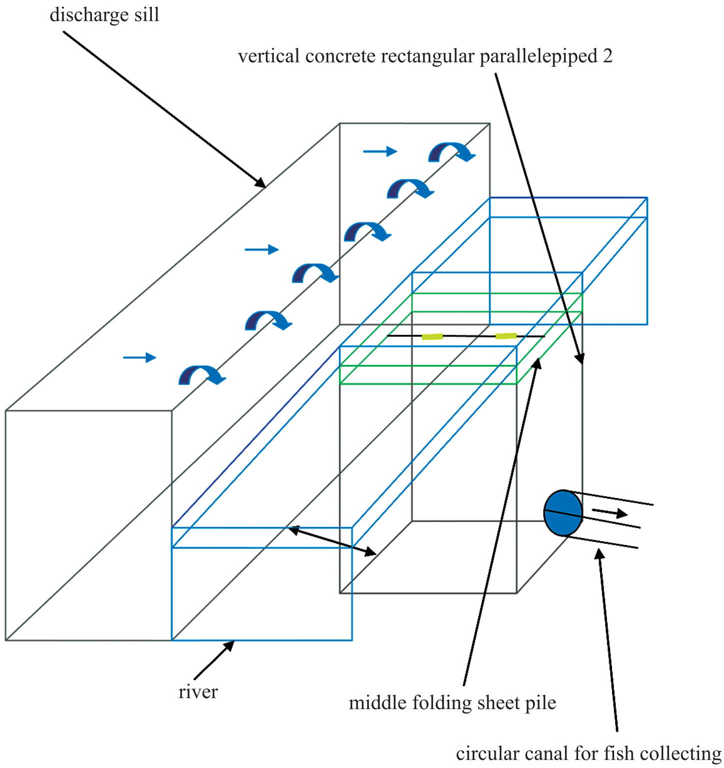

Fig. 6. Positioning the vertical concrete rectangular parallelepiped 2 – indicative scheme

A concrete pile is fixed near the vertical concrete rectangular parallelepiped 2 (Fig. 7). A winch attached to a metal cable is to be fixed on the concrete pile. This metal cable is, in its turn, attached to a metal ring. The metal ring is welded to the middle folding sheet pile (Fig. 7). The two winches on the two concrete piles situated upstream and downstream of the discharge sill are the same height; therefore the cable sliding the two winches is horizontally-oriented (Fig. 8).

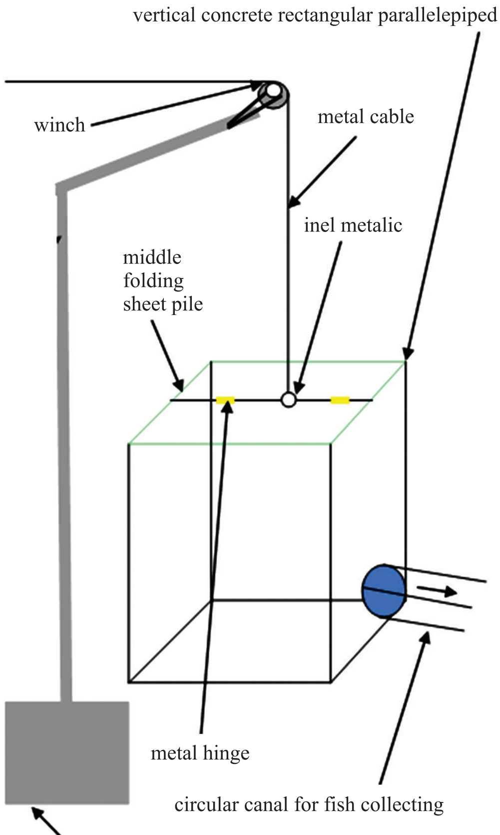

Fig. 7. Positioning the concrete pile situated downstream of the discharge sill – indicative scheme

In its original position, the stone parallelepiped is fixed by means of two folding metal stoppers (Fig. 9 and Fig. 10). These metal stoppers that support and block the stone parallelepiped have a pivotal role in system functionality by helping fish migrate above the discharge sill. The two sensors are fixed on two vertical concrete parallelepipeds and once put into motion these stoppers play an important role, the sensors systematically operate the perimeter by symmetrically exceeding the cross-section of each vertical concrete parallelepiped by one meter.

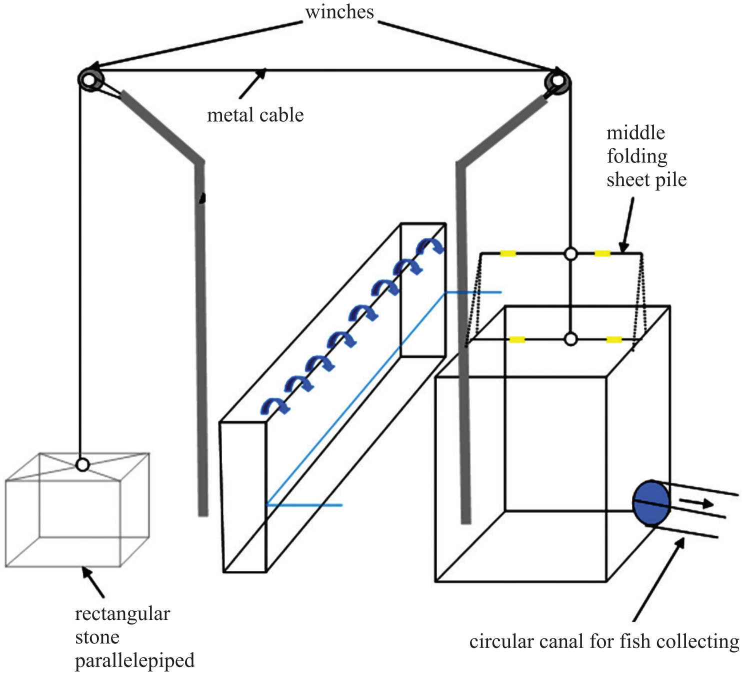

Fig. 8. Positioning the metal cable – indicative scheme

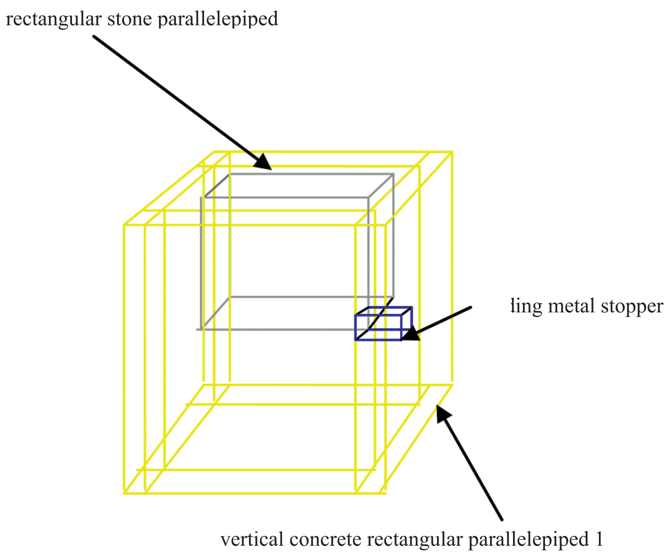

Fig. 9. Positioning the stopper located at the very top of the parallelepiped 1 – indicative scheme

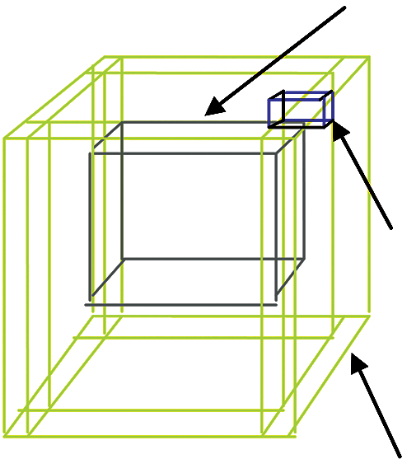

Fig. 10. Positioning the stopper located at the bottom of the parallelepiped 1 – indicative scheme

These stoppers withdraw into the concrete parallelepiped by the fish fauna sensors placed upstream and downstream on the two concrete parallelepipeds. The two stoppers work under the on-off principle of the automatic fasteners provided with sensors. All components of the on-off stoppers are fixed inside the concrete parallelepiped 1, inside a specially designed and fully waterproof area. The energy necessary for operating this locking system comes from a solar panel. Inside the first concrete parallelepiped there is a circular hole where underground ducts are built. When going down, the stone parallelepiped collects by absorption and directs them downstream of the discharge sill. The diameter of these tubes is between 10 cm and 100 cm (Fig. 11). In its highest position, the stone parallelepiped is tightly framed by a water resistant rubber sleeve so that water does not penetrate inside (Fig. 11). By using the absorption principle again, the fish are collected by folding the metal sheet pile. Upstream of the discharge sill, a concrete basin between 1–10 m depth is built. It must have a direct connection with the underground concrete canal provided with rectangular parallelepiped 2. The concrete basin has an immediate connection with the canal directly connected to the river, upstream of the discharge sill. The overflow in this basin is taken through an underground duct discharging all waters into the river downstream of the discharge sill (Fig. 12).

When bringing fish to the underground basin, water will flow over the metal grille and reach the previous level, after closing the middle folding sheet pile. The canals that fish move into, either to get upstream or downstream, are made of smooth concrete tubes in order to not injure the fish. Water flows gravitationally through these two canals and actually through all canals in figure 11 and figure 12. Because the ducts are inclined, there is no risk for fish in the river or underground basin to climb up. The overflow duct in the underground basin is equipped with a metal grill upstream, blocking fish passage (Fig. 12). The fish-redirecting system, where needed, can be made of floating rollers or by using low amperage electric fields.

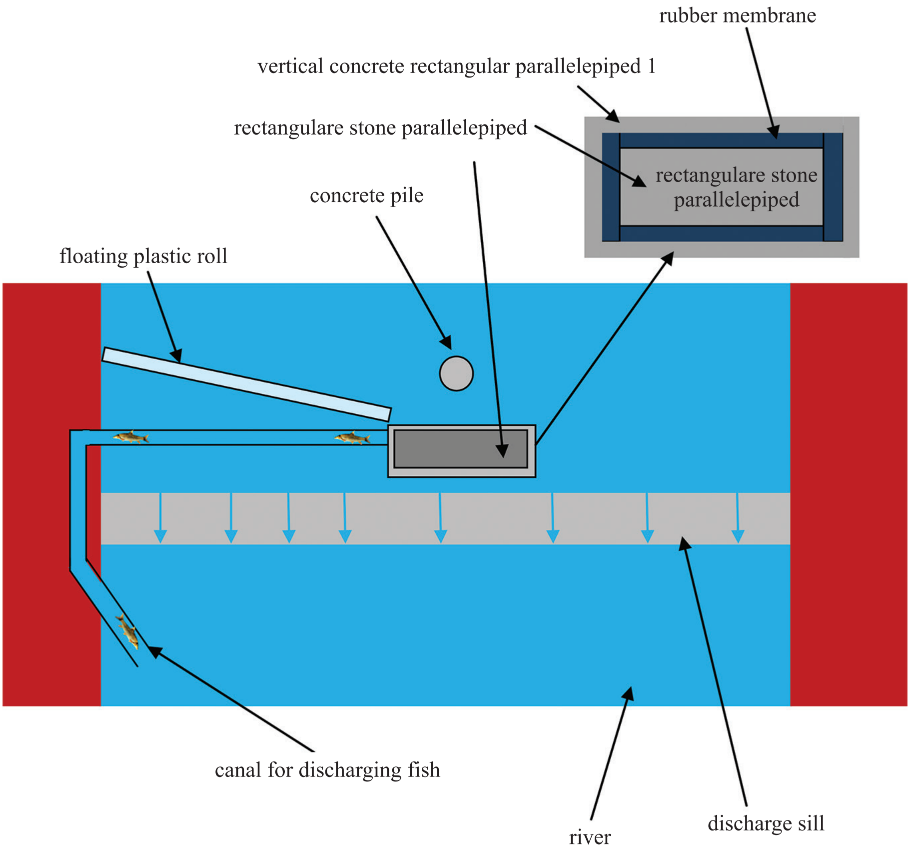

Fig. 11. Positioning the canal for discharging fish downstream of the discharge sill – indicative scheme

There is a fish fauna sensor located on the pole downstream of the discharge sill that, when detecting ichthyofauna, gives the signal to the top stopper to fold down which allows the stone parallelepiped to reach the vertical concrete parallelepiped base 1. Simultaneously with the top stopper, the stopper at the bottom of the vertical concrete parallelepiped 1 folds down as well allowing the stone parallelepiped to reach the base of the vertical concrete parallelepiped 1. As soon as the stone parallelepiped has reached the base of the concrete parallelepiped 1, the bottom stopper folds down again and supports the stone parallelepiped at the base of the concrete parallelepiped 1. The bottom stopper of the vertical concrete parallelepiped 1 is scheduled to close 30 seconds after or even more depending on the amount of the migrating fish. Reopening the system occurs after five seconds. Thanks to the winches and the metal cable, the minimum level of the stone parallelepiped coincides with the maximum height of the middle folding sheet pile and vice versa. The operating principle has four metal grilles concrete pillar the underground basin the outer canal for supplying the underground basin sub electromagnetic fields generator vertical concrete rectangular parallelepiped

2 middle folding sheet pile canal for discharging fish canal for maintaining a constant water level within the basin river stages (Fig. 13). Where appropriate, i.e. where there is a discharge sill longer than 10 meters, several solar panels can be used for multiple systems of fish migration.

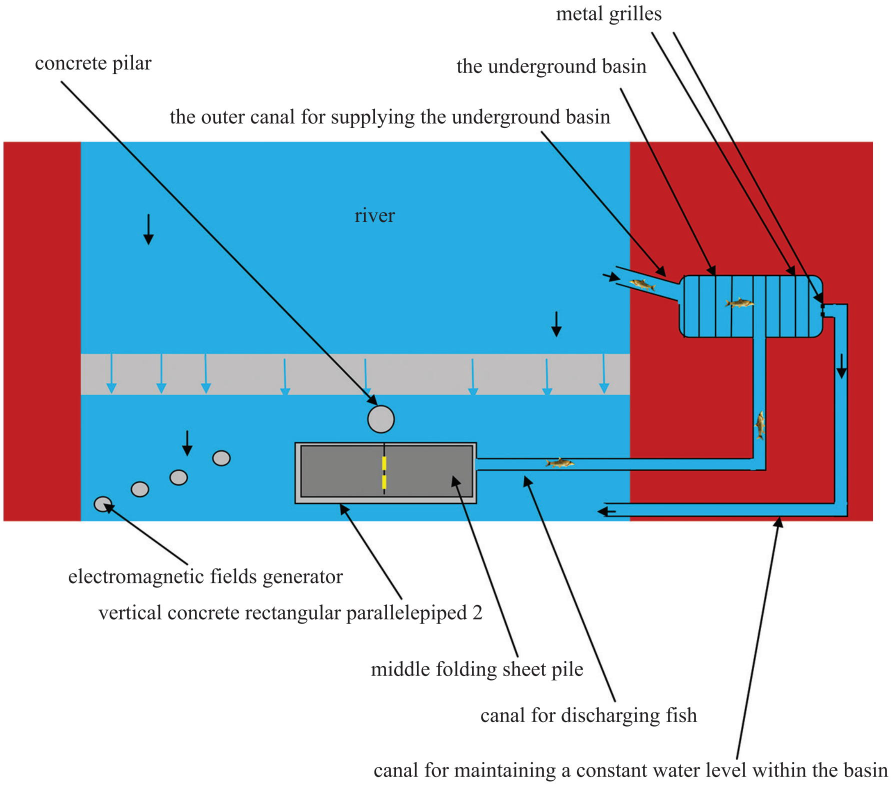

Fig. 12. Positioning the underground basin – indicative scheme

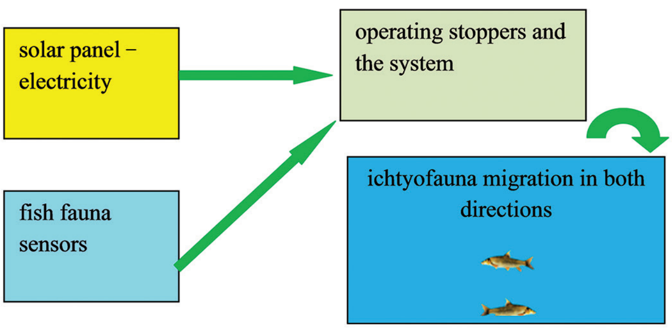

Fig. 13. Scheme of operation system regarding the ichtyofauna migration above the discharge sill – indicative scheme

RESULTS AND DISCUSSION

The need to address fish migration in engineering systems across various hydro--construction methods represents important and essential elements. This is accomplished automatically in the solution proposed herein, with fish attracting water (gravitational) reaching inside concrete rectangular parallelepipeds situated upstream-downstream of dams (discharge sill), and due to the rapid movement of rectangular stone in conjunction with folding the middle folding sheet pile fish will be attracted to enter into the system containing water. Once entered into a system, fish can migrate upstream or downstream to the discharge sill. Another problem for fish (ichthyofauna) migration is the speed of flow through the system that can prevent some of the ichthyofauna from reaching their destination. The solution proposed here has solved this impediment as the fish can swim only in the underground basin and in the water supply canal. The water speed in the water supply canal is lower than that of the river in the study area so fish can easily swim upstream to the discharge sill. Another problem with fish migration systems is their structure that can injure fish in both the ascent and descent. This impediment has been resolved by the proposed solution as well as the case that the materials they are made of do not injure fish but are meant to protect. Another advantage is that this system can be used for many different species, including migratory fish species such as beluga and sturgeon. This system is proposed for migratory species but can also be used by another different species including non-migratory ones. The system is not complicated and high quality components can function for a long time and the system is only affected by consumables (hinges, bearings, etc). This article represents a new and innovative scientific concept and a new technology for fish passage that allows migration over the discharge sills. This concept only presents a design solution to improve fish passage and assessments and discussion of results will take place during construction and especially while monitoring after completion. The efficacy of this system lies in positioning to the threshold of the discharge sill and the functional multiplicative number. Whether it is that fish migrate upstream to the left against the direction of flow and the other fish move downstream to the left in the direction of water flow (when there is diagonally positioning system – Fig. 14), the same diagonal positioning system applies if the other fish migrate upstream right opposite of the flow direction and the other fish migrate downstream to the right of water flow, the system can be positioned depending on the route of movement. If the system is positioned diagonally and then fixed in the river bed, the concrete pillars armed with winches can be positioned horizontally. Metal cable winches complete the direct connection with the winches that raise the stone parallelipiped and the middle folding sheet pile. If there are many different species of migratory fish, we can create up to 5 systems on a mediumsized river.

The winches close system that the metal cable raises or lowers the stone parallelepiped and middle folding sheet pile are vertical and the other winches are horizontal (Fig. 15).

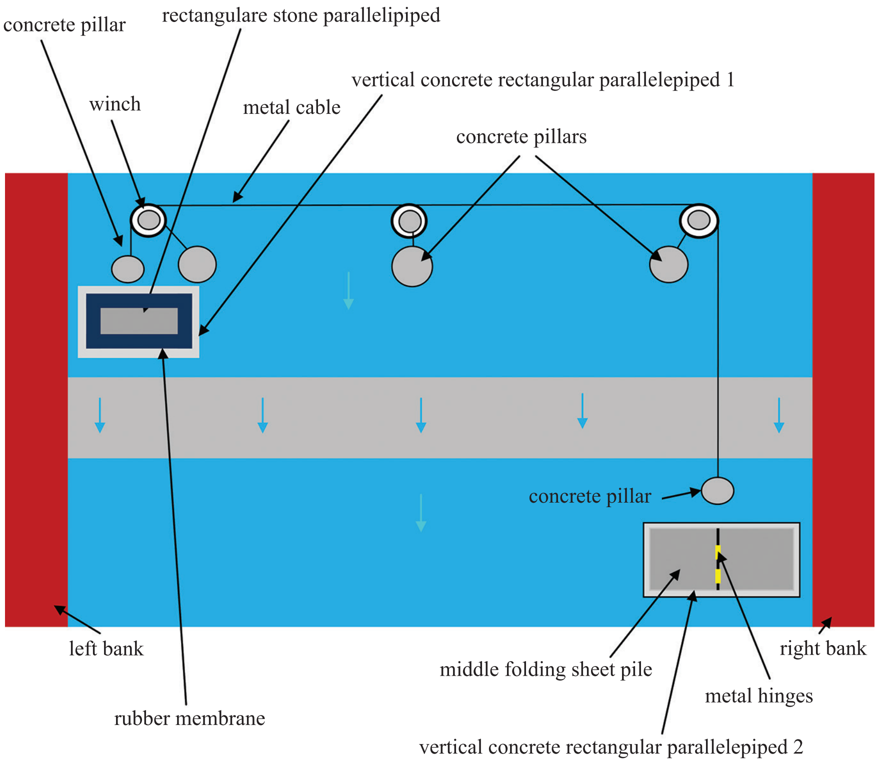

Fig. 14. Positioning system fixed in diagonally – indicative scheme

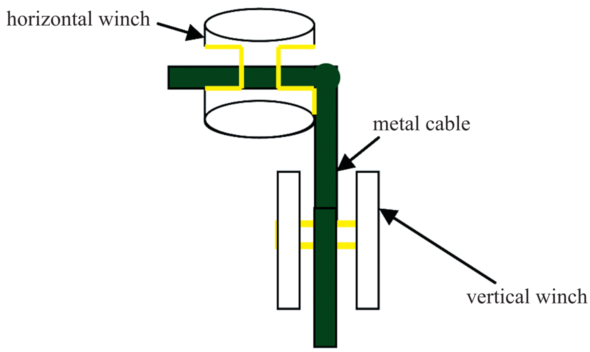

Fig. 15. Positioning the winches

CONCLUSIONS

This system can be designed from components without much difficulty and the easy assemblage, lack of electrical consumption from the national grid, the ichtyofauna protection when moving upstream and downstream into the canals, and the gravitational water flow makes this solution a real possibility in improving and restoring ichtyofauna migration worldwide. Using high quality components, this system can function for a long time without repairs and only routine maintenance as necessary. All metal components must be resistant to corrosion. During winter and when in areas where there is no seasonal fish migration, the fish fauna sensors operating the whole system can be disabled. The system can run at full capacity both for the upstream-downstream migration and vice versa which is almost impossible for classic upstream systems of fish migration. Therefore, fish can migrate upstream and downstream of the spillway sill at the same time. This system involves average costs, does not cause pollution and is safe for of all fish passage regardless of species, age, and/or effort capacity as the swimming distance against the current is minimal and runs under the best conditions. All engineering calculations will take into account the characteristics of migratory fish species, the spillway sill size, the rivers peculiarities and also the local climate.

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ZASADA DZIAŁANIA I PROJEKT SYSTEMU WSPOMAGAJĄCEGO DLA RYB MIGRUJĄCYCH W GÓRĘ I W DÓŁ CIEKU WODNEGO

Streszczenie. Przemieszczanie się ryb w rejonie budowli wodnych wymaga specjalnych przedsięwzięć technicznych, ułatwiających rybom przepłynięcie. W związku z tym poszukuje się nowych technik, które usprawniłyby migrację ryb. Artykuł dotyczy problemu nieprzerywania ciągłości rzek przez budowle wodne w kontekście Ramowej Dyrektywy Wodnej Unii Europejskiej 2000/60/EC (WFD). Także Prawo wodne (art. 107, z rozszerzeniem T/2006 OM 1163/2007), które również odzwierciedla dyrektywy europejskie, podejmuje temat utrzymania ciągłości przepływu rzek poprzez wprowadzenie różnego rodzaju konstrukcji hydrotechnicznych (np. przepławki, kanały obiegowe), które ułatwiają zwierzętom migrację. Celem artykułu jest prezentacja systemu wspomagającego przepływ ryb w górę i w dół cieku wodnego.

Słowa kluczowe: ciągłość cieku, migracja ryb, zapora, ciek wodny, przepławki

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