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FACILITATION FISH MIGRATION ABOVE THE DISCHARGE SILL LOCATED ON THE IALOMIŢA RIVER NEAR CAVE IALOMICIOARA

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Abstract
Longitudinal connectivity restoration of watercourses is a major duty for scientists (biologists, hydro engineers, chemists etc.) that, by the means of technical exchange via conferences, projects, workshops, universities, and institutions demonstrate the major importance of a natural (non-anthropic) function of the lotic ecosystems. On the Ialomiţa River, the discharge sills located downstream from Padina chalet block the migration of some fish species, such as the brown trout (*Salmo trutta*) and the bullhead (*Cottus gobio*), prohibiting access to foraging areas and springs. Water Framework Directive 60/2000 / EC provides a legal framework for restoring "good status" of longitudinal and lateral connectivity of watercourses. Our proposed solution I can be applied to other discharge sills and dams sized between 3m and 6m high, and, where feasible can utilize existing power sources of some discharge sills. Solution II's concepts allow the dimples inside the concrete plate to serve as a rest and recovery area for migratory species. Such benefits that ensure upstream/downstream fish migration while allowing discharge management to continue is unattainable in conventional systems. After solution II is applied the discharge sill does not lose any baseline characteristics while maintaining the original hydro-technical design objective, flood dissipation.
Keywords: fish migration, ecobiome's functionality, Ialomiţa River, longitudinal connectivity, dam.

1.INTRODUCTION

Conservation of the valuable National Park Bucegi avifauna sites necessitates a great coordination of the policy makers, including NGOs, the scientists and volunteers. Unfettered development within the Bucegi Mountains remains the greatest threat to protect and preserve these ecological treasures. Free migration of fish in the study area and watershed area in general, represents an important element of the optimal functioning local ecosystems. Construction across stream channels (discharge sills) partition Brown trout, bullhead and the endangered Golden trout habitats. Lack of exchange through habitats drastically reduce productivity and capacity of these species. This paper describes some engineering solutions that help fish overcome these obstacles. Fish migration systems over discharge sills and dams can't be achieved only by relying on gravitational flows of water due to hydraulic drops and velocities that exceed these species swim performance. Structure designers must take into account other parameters such as hydraulic and mechanical energy, channel roughness, traction, and redirection systems. Below we present a crossing solution over the discharge sill in the Ialomiţa River, near Cave Ialomicioara.(Figures 1a and 1b).

Like any field conception, design and construction of fish migration systems across different transversal hydraulic structures is continuously improving. Therefore new relevant and achievable ideas are welcome, and time will demonstrate their effectiveness. Solution I and Solution II concepts do not go beyond reasonable scientific patterns, but add extra values to discharge sills where site constraints limit lateral solutions.

The value principles cannot be disputed, but elements of the solutions they rely on can. System-related costs, system efficiencies, location for implementing the system etc. could be disputed. However the engineering (hydraulic) principles are somewhat universal and amenable to practitioners. Engineering calculations in collaboration with biologists' (and other experts) can achieve design solutions to migration systems providing valuable contributions to the fish passage field. The concepts we propose here are the scientific foundations for this growing field. Expensive solutions are not necessarily efficient and complex solutions cannot guarantee maximum efficiency. Practical design typically solves many of the problems related to the efficiency of the newly created fish migration systems. These two solutions are reasonable ways that do not require extensive calculations and funding. The authors' experience and enthusiasm mainly guarantee these solutions and provide an impetus for the creation of new eco-technic solutions.

Figure 1a. Discharge sill near Cave Ialomicioara

2. MATHERIALS AND METHODS

A better education for the citizens, extension of the protected sites, increased capacity of the conservation-minded institutions already engaged and those starting up, and practical performance-based management schemes for valuable sites are some main elements in connection with which the Natura 2000 network can enhance the EU countries' nature conservation (Bănăduc, 2007, 2008, 2010, 2011; Bănăduc et al., 2012; Curtean-Bănăduc and Bănăduc, 2008; Papp and Toth, 2007). The hydromorphological pressures created by the presence of transversal constructions can lead to the interruption of longitudinal connectivity of rivers (Fehér et al. 2012). Addressing flow regime modifications and migration/mobility stoppages are of high importance, but practically-engineered designs are becoming more available and consulted upon to restore natural systems (Kay and Voicu, 2013).

Alluvial forest destruction, hydrotechnical works, intensive agricultural work, industrial-scale activities can fragment natural habitats, disrupt lotic ecosystems in qualitative and quantitative terms and defragment natural habitats. (Voicu et al. 2015). Improving longitudinal connectivity completes the watershed level connectivity that also connects with functional floodplains and wetlands (Ickes et al. 2005). Lateral connectivity to floodplains facilitates essential nutrient exchange between the river channel and floodplain (Thoms 2003), thus connecting the channels to the most productive and diverse ecosystems on earth (Tockner and Standford 2002), contributing more than 25% of all terrestrial ecosystem services (Tockner et al. 2010). Natural cascades, high gradient rapids and riffles, and anthropogenic barriers such as dams limit aquatic habitat connectivity and fish migration (Thorstad et al. 2008). Fish migration timing windows are typically coincident with adequate stream flows (Reiser et al. 2006). During fish migration, hydrological barriers can cause migration delays that may affect fish reproduction (Ovidio and Philippart, 2002).

A key concern with respect to biodiversity conservation is understanding the drivers and implications of altered ecological connectivity. Anthropogenic fragmentation primarily affects terrestrial and aquatic ecosystems and impacts the connectivity among populations and habitats (Pringle, 2001; Lindenmayer and Fischer, 2006). Low levels or increased connectivity humans are due to habitat types and spatial scales. The evolutionary trajectories of populations and species are affected by changes in biota to the humans. (Allendorf et al., 2013). Negative effects are well known in river morphology and their ecological integrity (Dynesius and Nilsson, 1994; Stanford et al., 1996; Bernhardt et al., 2005). Culverts, dams and weirs have worrying effects on native fish populations. The "fish passage barriers" like said the experts loss of genetic diversity and changes in community composition, reduce access to essential habitats, leading to restricted range size (Jesse R. O'Hanley , Jed Wright , Matthew Diebel , Mark A. Fedora, 2010).

3.RESULTS AND DISCUSSION

Solution I

The discharge sill of 4 meters high and 8 meters wide is located on the Ialomiţa River (figures 1a & 1b) near Cave Ialomicioara, which in turn, is situated at about 10 km from the spring source of the Ialomiţa River. Water velocity upstream of the discharge sill is 1.4m/s, and the flow is $0.8m^3/s$. The shallow sheet flow is a hydraulic drop and velocity barrier for all species migrating upstream.

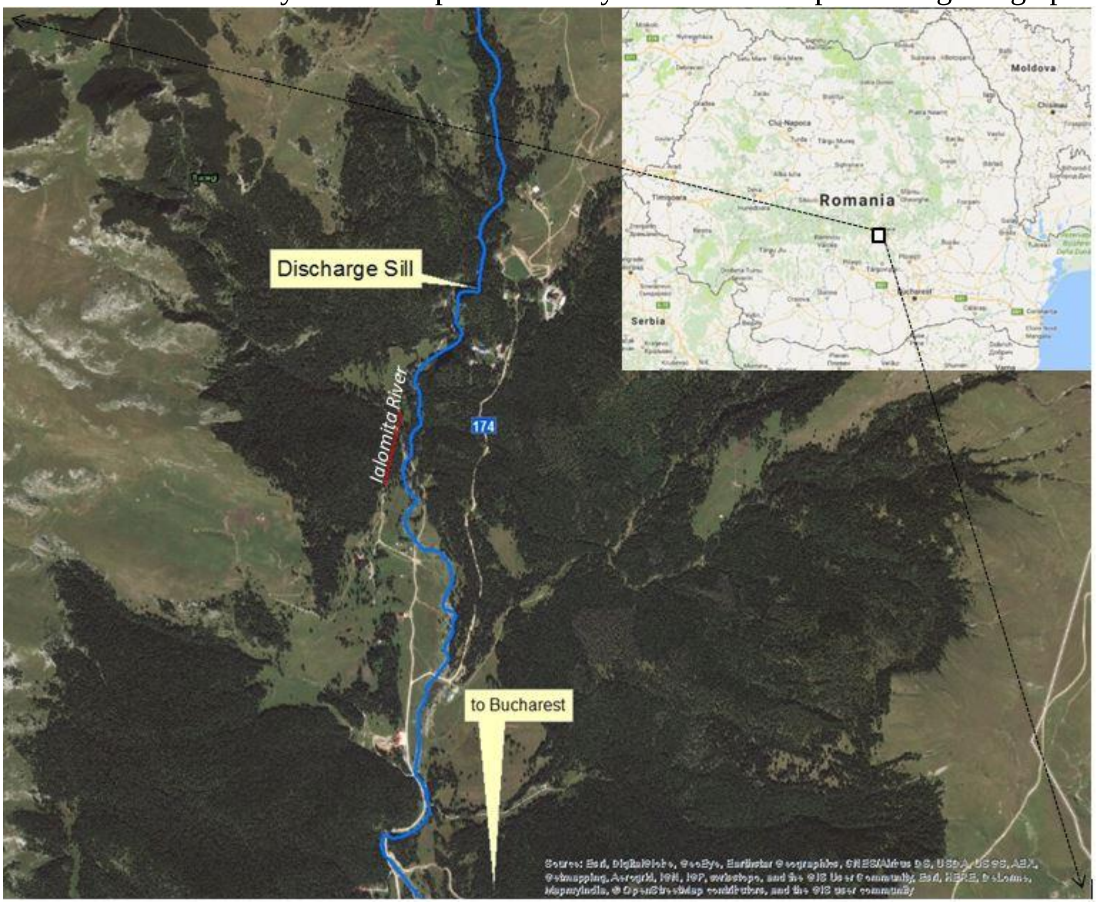

Figure 1b. Location of the discharge sill

On the right bank upstream of the discharge sill (at about 8m) a concrete water intake should be built in order to fix a pipe equipped with an automatic valve which regulates the 6 l/s flow passing through the pipe. The diameter of the pipe should be 10cm. The downstream end of the stainless steel adduction pipe will be at 8 meters downstream of the discharge sill, on the right bank of the river. The downstream end of the pipe is in a 1.5 m^2 concrete basin (figure 2 - Detail shown in Figure 3) at about 8 meters distance from the discharge sill. The difference in level between the upstream and downstream ends of the pipe is 3m.

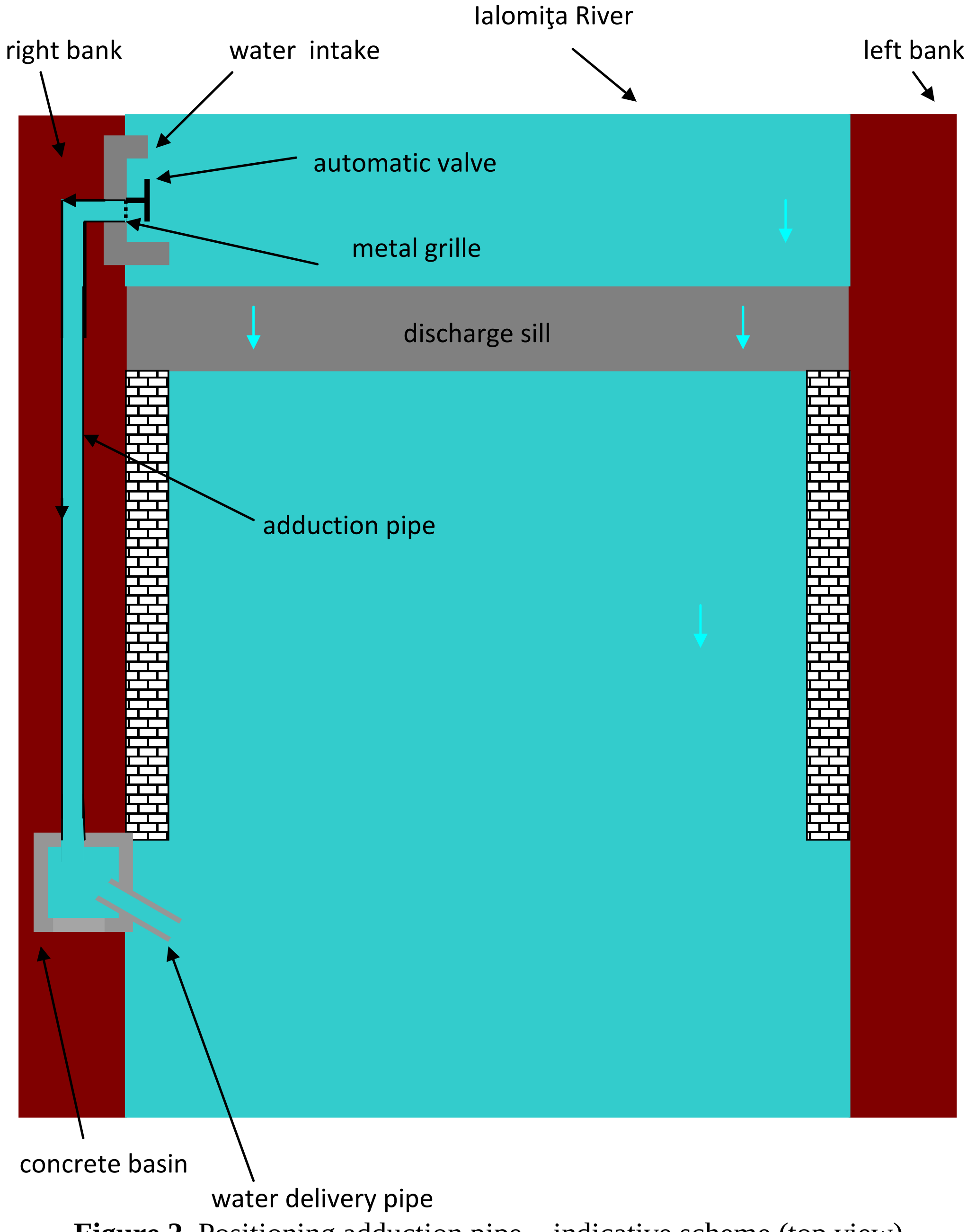

Figure 2. Positioning adduction pipe – indicative scheme (top view)

Inside the concrete basin a metal axle (bar) is fixed in concrete basin walls (figure 3) A disk is welded to this metal axle. Some metal blades are welded to the metal disc (Figure 4) such that the metal disc rotates due to the water in the pipe engaging the blades based on the mill principle. A dynamo is fixed to the metal disc (Figure 5) that produces electricity. The water level in the concrete canal is more than 20 cm lower than the bearings level and remains constant due to the pipe working as an overflow (Figure. 3).

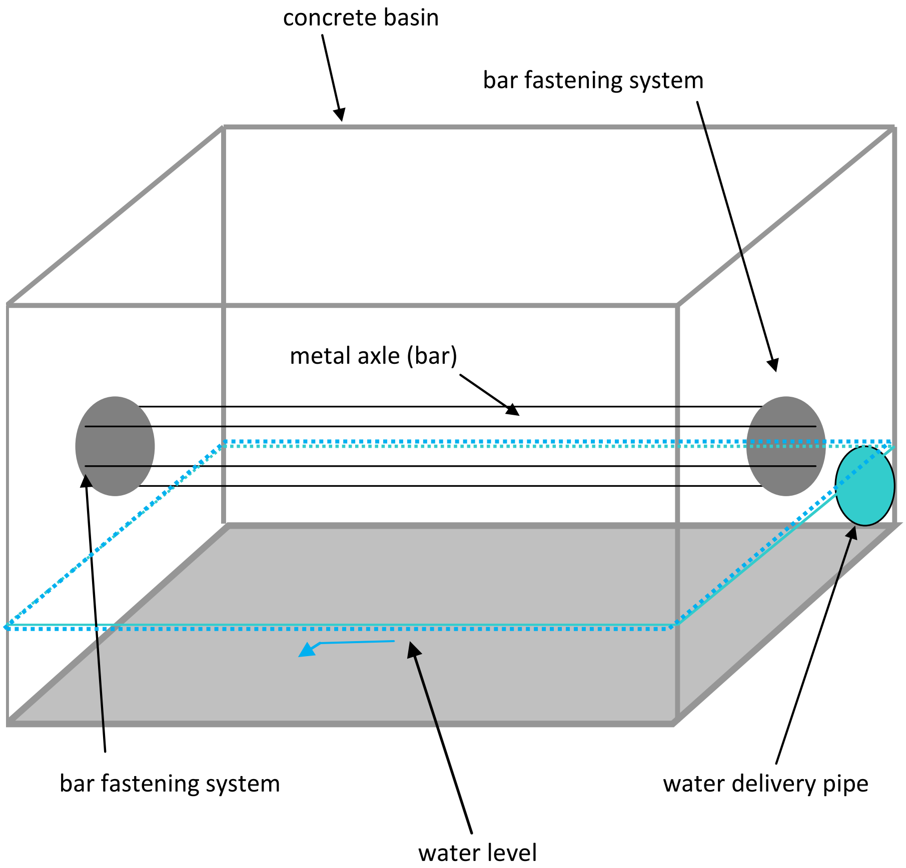

Figure 3. Position the metal axle inside the concrete basin – indicative scheme

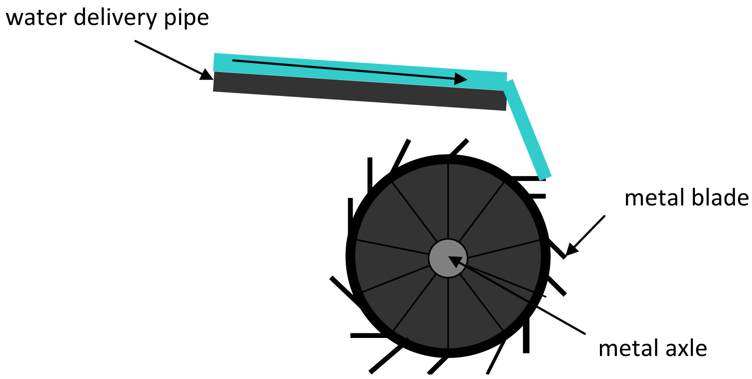

Figure 4. Positioning blades on the metal disc – indicative scheme (side view)

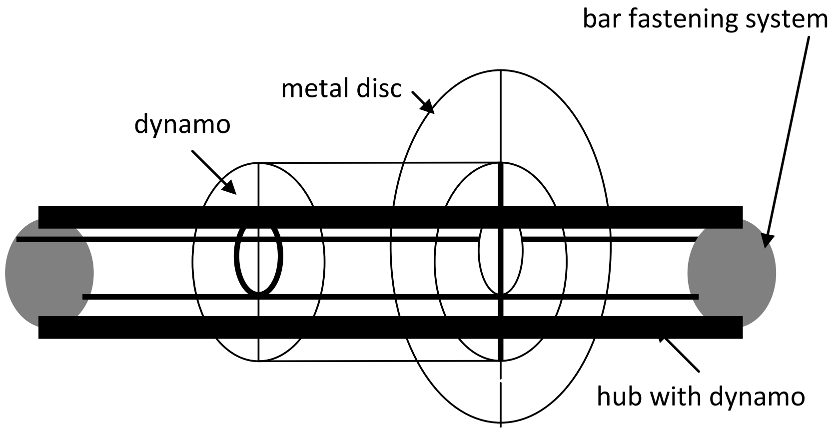

Figure 5. Positioning the dynamo on the metal axle – indicative scheme

At about 20cm from water chute and 40 cm from the discharge sill, there will be two stainless steel guide bars fixed at 3 meters distance of each other. Other two bars are fixed 0.6m under the first ones and 1.5 m from the banks of the river (figure 6).

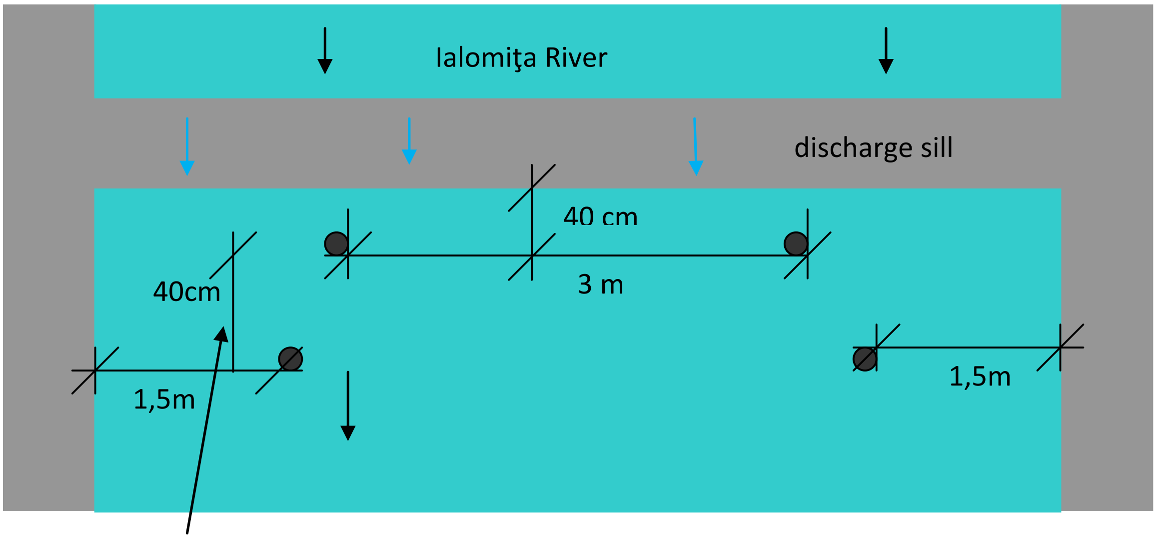

Figure 6. Positioning the metal bars- indicative scheme (top view)

A metal frame having two mobile surfaces and other three fixed surfaces is fixed to the two stainless steel side bars. All surfaces of this rectangular basin are made of thin stainless steel grating. The bottom surface of the basin is oblique, thus forming an inclined plane (Figure 7). Basin is fixed to the side metal bars by the means of some metal clamps that slide on these bars (Figure 8).

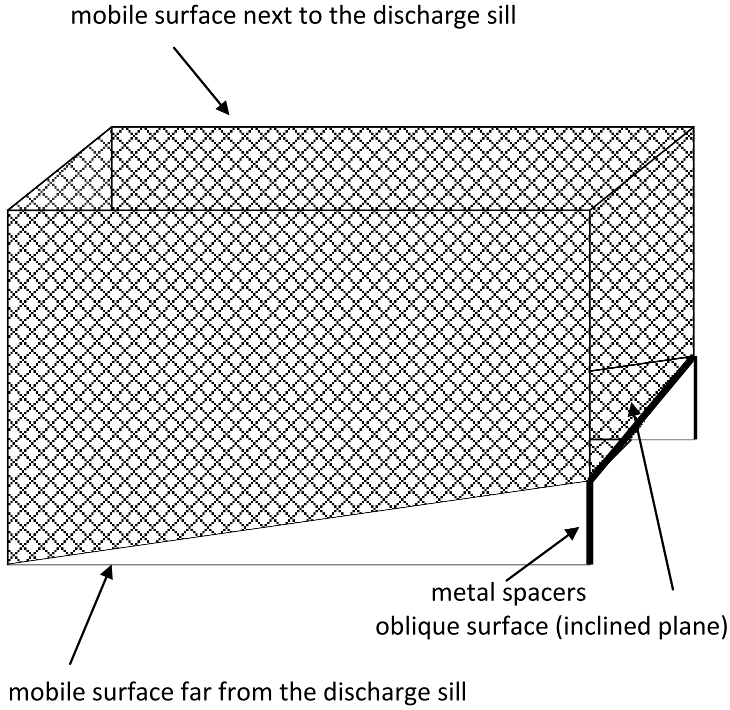

Figure 7. Mobile basin - indicative scheme

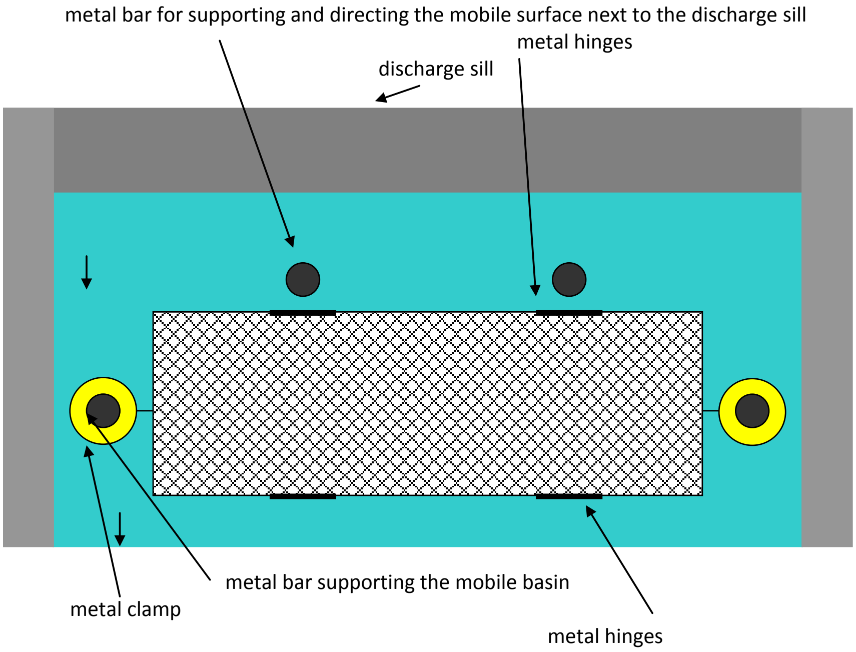

Figure 8. Location of the mobile basin against the metal bars- indicative scheme (top view)

This basin is rectangular and swivels vertically. On both sides there are two concrete pillars about 6 meters tall at 10 cm from the side bars. The end of each pillar is provided with an electric winch and a accumulator powered by the dynamo located on the concrete basin shaft on the right bank of the Ialomiţa River(Figure 9). Winches are fastened to the fixed horizontal surfaces (Figure 9). The accumulators are supplied to the maximum with electricity achieved by the dynamo fixed to the metal shaft of the concrete basin. A sensor switches off the power supply when the accumulators were charged and redirects it towards the national network or switches off the automatic valve. When the accumulators have little electricity, the sensor restores the accumulators power supply and so the system can operate for long time. The mobile surface far from the discharge sill is provided with two bars welded perpendicularly to it (Figure 10).

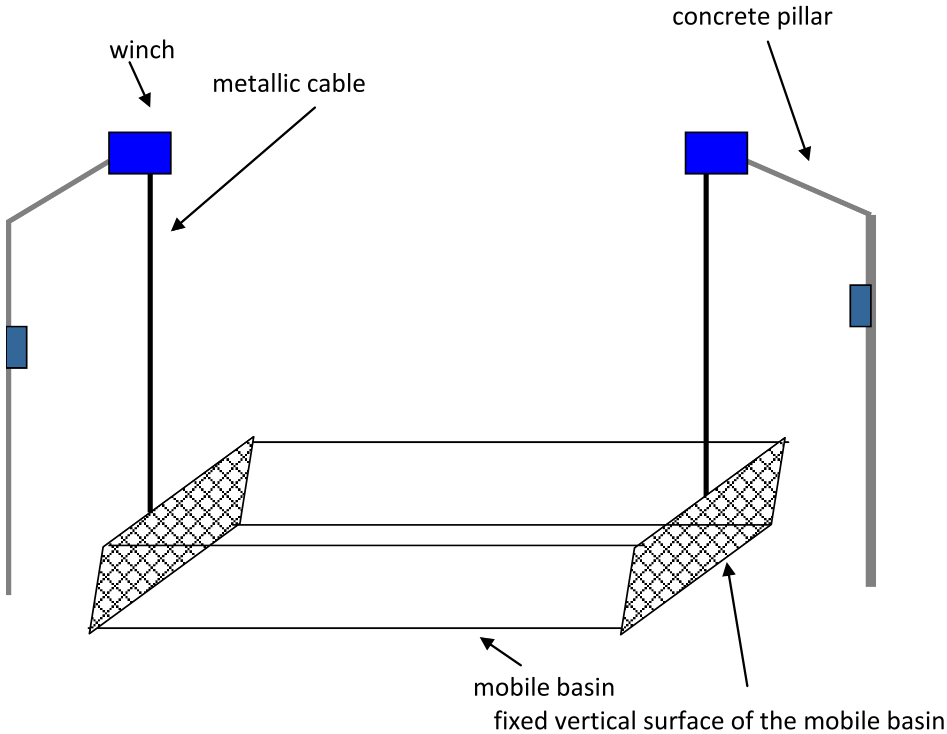

Figure 9. Location of the winches and accumulators- indicative scheme

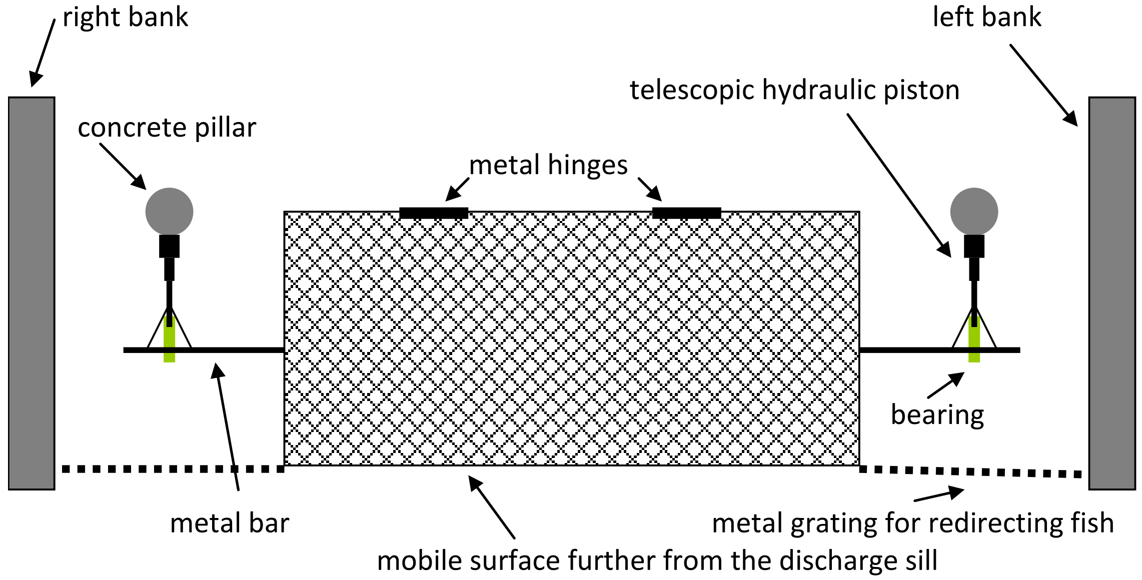

Figure 10. Location of the metal bars and telescopic hydraulic pistons - indicative scheme

These welded bars will help the basin surface fold using the telescopic hydraulic pistons. As the telescopic hydraulic pistons can turn about the mobile surface, they are fastened to two bars provided with a bearing each. In its turn, the bearing is fixed onto the bar welded perpendicularly to the mobile surface (Figure 10). The telescopic hydraulic pistons are connected to the concrete pillars by the means of some clamps equipped with metallic beads offering the possibility of sliding vertically so that the whole system for fish migration can move vertically (Figure 10).

The area equipped with telescopic hydraulic pistons can stand horizontally, thus facilitating the circulation of fish above it. A fish fauna detection sensor determines the operation of hydraulic telescopic pistons, thus allowing the surface far from the discharge sill to fold. After folding, the fish are caught in the mobile basin.

After completing the folding process, the sensors on the pillars supporting the winches switch them on and the basin lifts to the maximum level, when the bottom surface of the basin (inclined plane) and the gravitationally sliding surface create an inclined linear plane allowing the fish to be placed upstream of the discharge sill (Figure 10). The mobile surface near the discharge sill relies on the metal guide bars on both stationary and folding positions (Figure 11). Being equipped with metal grating, the mobile surface next to the discharge sill represents an effective system for fish attraction and spreading. After standing for 30 seconds at the maximum level, the same sensors sending the lifting signal for the mobile basin, command it to lower. After the basin has stabilized on the Ialomiţa river bed, another sensor sets in motion the telescopic hydraulic pistons folding the mobile surface horizontally further from the discharge sill.

Except from performing a monthly check, the qualified personnel responsible for the fish migration system has no reason to visit the project area. This system can be used for many migratory species of fish including herring and salmon. For discharge sills longer than 10 m, several systems that work independently of each other must be used. They should not allow migratory fish to be blocked downstream from the discharge sill. In order to help fish moving down the discharge sill a bypass located on the right side of the bank can be used. This bypass should be installed at 1.50m distance from the water supply system. This system is equipped with a pile for fish redirecting (figure 12). Downstream from the pile, at about 30cm, a stones diversion for redirecting ichtyofauna is built (figure 12). During low flow periods the majority of water is redirected to the bypass. The water can still flow easily among stones for smaller aquatic species and nutrients to remain and pass through the main channel. During higher flows the stones can serve as a roughened channel dissipating energy because we expect some organisms to pass over the sill during flood stages. However this passage is in a less injurious manner because of deeper downstream waters during flood stages.

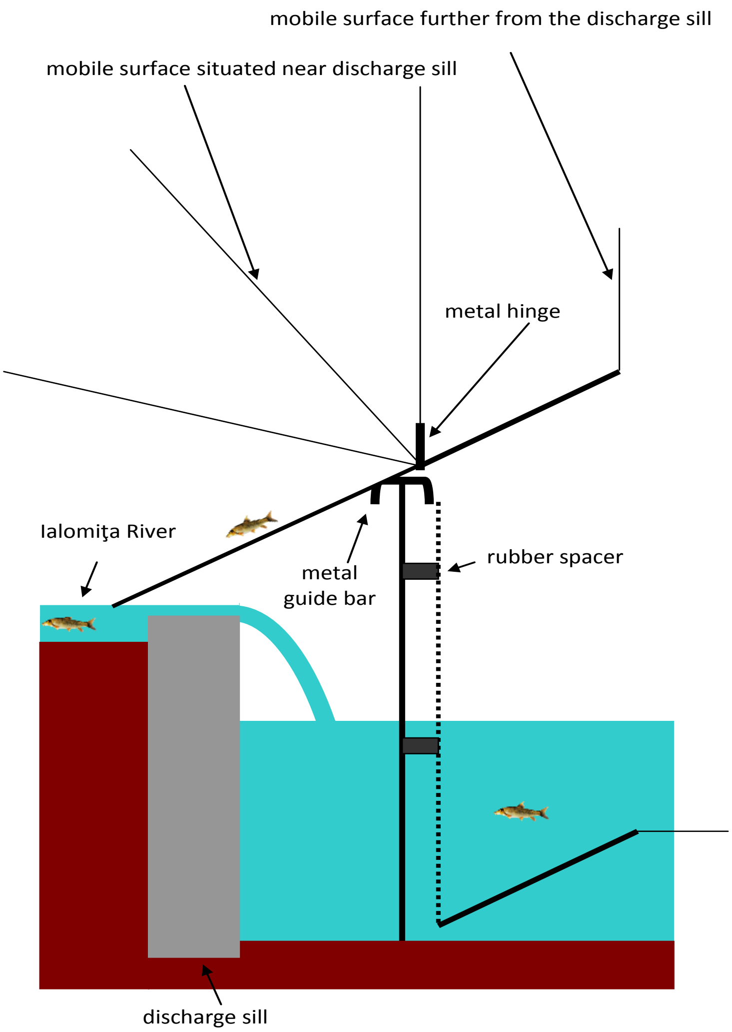

Figure 11. Maximum level of the mobile basin- indicative scheme

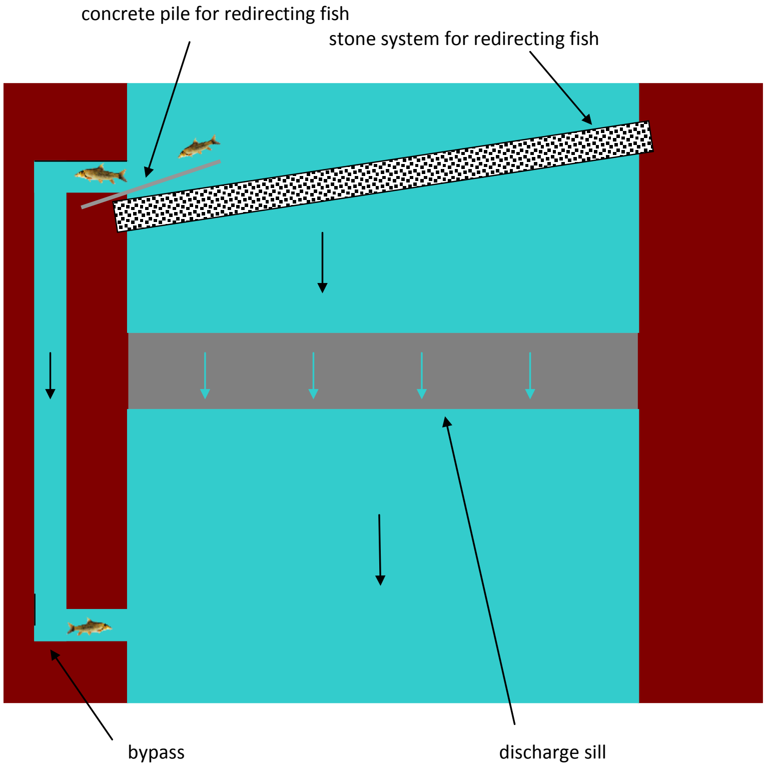

Figure 12. System for fish migration downstream from the discharge sill- indicative scheme (top view)

CONCLUSIONS

A byproduct of this structure is the ability to generate electricity which can meet the functional needs of the structure and generate excess supply for a rural area. We feel that the approval of such structures will be favored by national hydro construction companies since it does not interfere with the function and integrity of the discharge sill structure. In former communist countries, especially in Romania, any intervention of a hydro construction structure is discounted even if it can bring major benefits to local ecosystems. However, these type of retrofits meet the new stewardships mandates for watersheds. Maintaining this solution is not expensive because energy consumption required for operating winches, the locking and unlocking sensor for the automatic valve and the fish fauna sensor is achieved by onsite hub dynamo generation by the means of gravitational water fall. All components of this fish migration system upstream and downstream from the discharge sill are stainless steel or other non-corrosive material affording long-life and low maintenance. In places where the hydro electricity cannot be generated, some solar panels can be used. Due to its scalability, efficiency and affordable installation and operational costs the proposed solution has wide application potential in rivers of the world.

Solution II

Another solution for fish migration above the discharge sill near Ialomicioara Cave is providing fish passage through a concrete canal (concrete ramp and glass coating passing through the discharge sill). A rectangular concrete basin of maximum 20 cm depth, 3m length and 1.5m width is to be built on the Ialomicioara riverbed at the upstream end of the canal. This basin is built at 5m distance from the discharge sill (Figure 13). The basin is always full and is provided with front crenels through which fish can climb and descend. Redirecting fish from upstream towards the basin is achieved by using low-voltage electromagnetic fields generators (Figure 13).

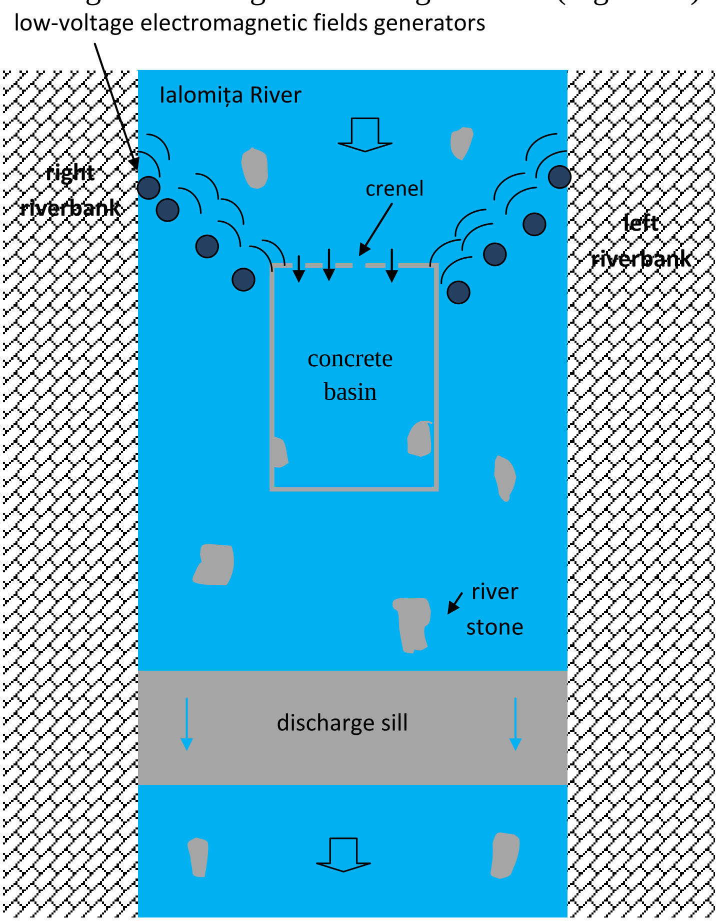

Figure 13. Positioning the fish catchment/arrival basin

Inside the concrete ramp (about 40 cm thickness), which is designed for fish migration upstream – downstream of the discharge sill, there are dimples designed for fish fauna resting and variable-sized river stones used as energy dissipaters and fixed on the ramp (Figure 14). Before reaching the discharge sill, the ramp goes underground and is tightly covered by a canal-shaped rectangular clear glass (glass coating system) 180 degrees in regard to water circulation direction (figure 14). This glass facilitates fish migration on the platform due to water inside, but also provides the necessary light for fish migration. In order to provide a high transparency, this glass coating system is framed by two durable plastic sheet piles positioned perpendicular to the discharge sill (Figure 14). The durable plastic sheet piles maintain a simulated stream flow over the migration system which provides a near-natural environment for the fish.

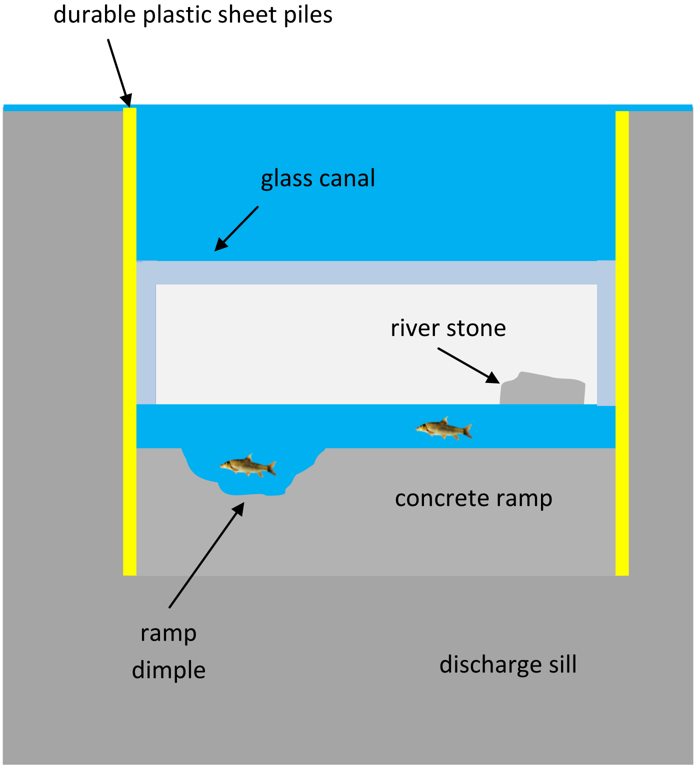

Figure 14. Hermetic positioning the canal on the concrete plate for allowing fish migration (side view)

A rectangular window is provided into the discharge sill through which both the concrete plate and the plate covering canal should pass (Figure 15).

Only the fish migration system and no water or other floating objects can penetrate the window. About 30 cm after platform leaves the discharge sill (through its window) it turns left, being supported by concrete poles fixed in the river (Figure 16). After leaving the window of the discharge sill, the platform turns left and is no longer covered (only exterior glass surfaces remain fixed to the platform). Therefore, a distance of about 30cm is required as water flowing from the discharge sill not to reach the concrete platform and cause migrating fish any mess eventually. When leaving the discharge sill and just before turning left, the platform is protected by a transparent and durable glass roof (coating system). This roof is fixed to the discharge sill (Figure 17).

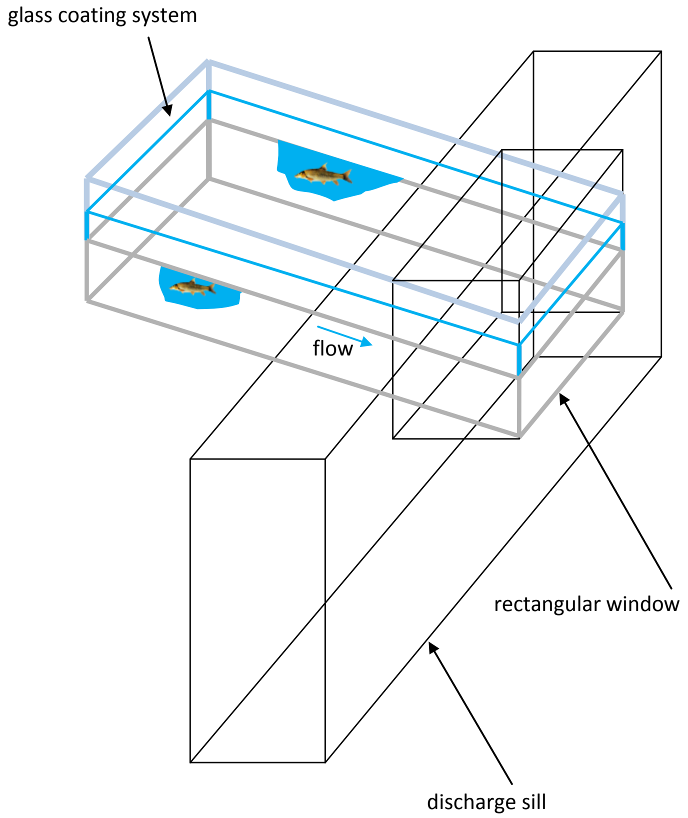

Figure 15. Positioning the concrete platform and the glass coating system inside the discharge sill - indicative scheme

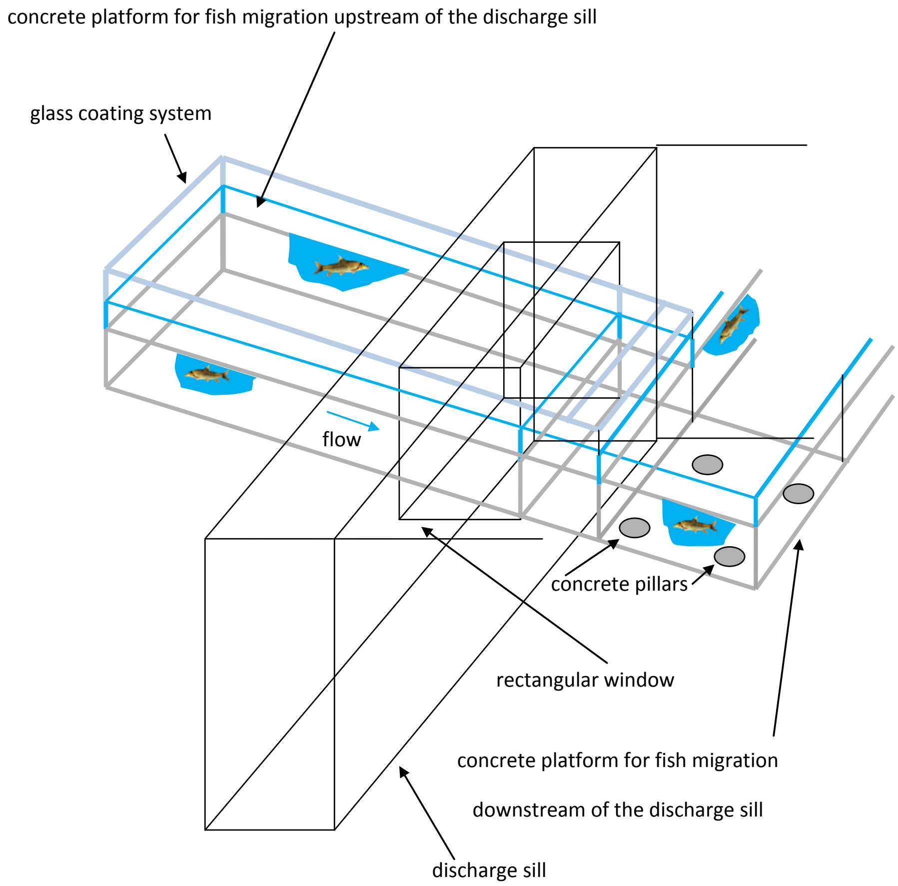

Figure 16. Positioning concrete platform for fish migration upstream and downstream of the discharge sill- indicative scheme

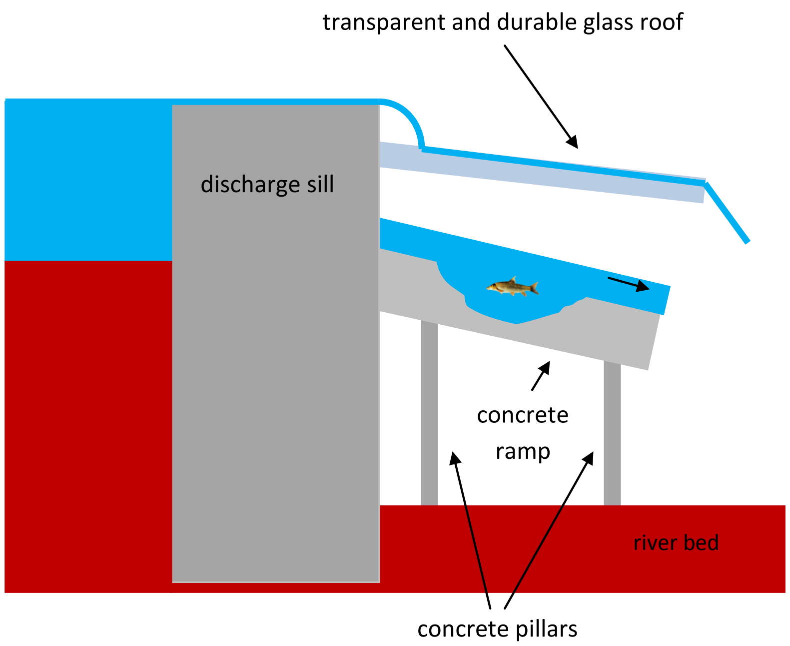

Figure 17. Positioning the transparent and durable glass roof - indicative scheme

At one point the platform will turn right and will be supported by concrete pillars up to a rectangular basin, which in turn, is linked to the other two basins by the means of some rectangular crenels, where water flows in the Ialomița River (Figure 18).

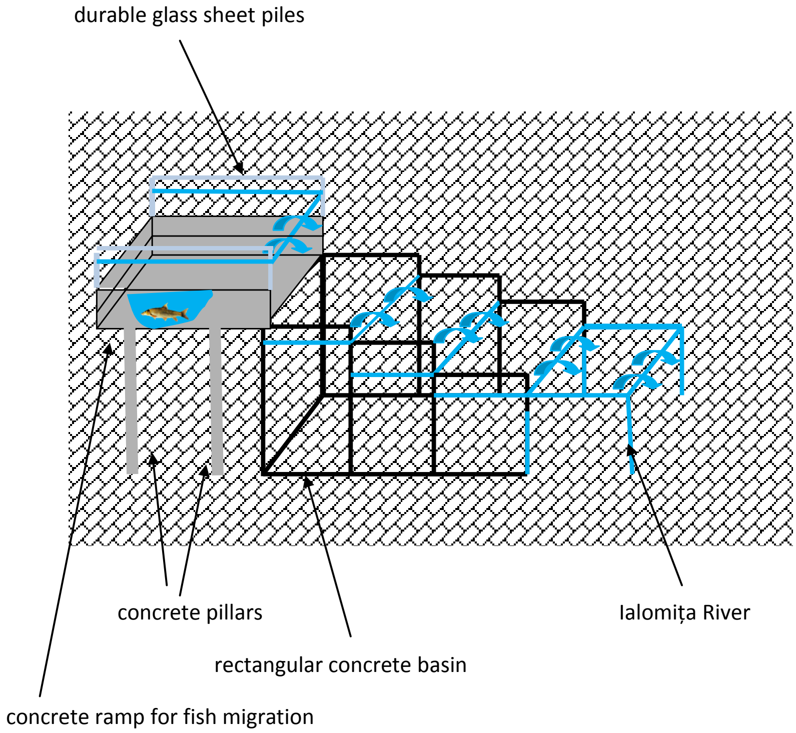

Figure 18. Migration system downstream of the discharge sill - indicative scheme

Slope and water velocity similar to the Ialomița River's (even smaller) can be simulated in the study area. This solution only uses gravity flow and offers maximum protection in case of floods. It can also be adapted to many migratory species including migrating salmon species par excellence.

CONCLUSIONS

Longitudinal connectivity represents a key element in the functioning process of lotic ecosystems (watercourses). The proposed solution solves this problem by the means of the discharge sill near Ialomicioara Cave. In many cases, restoring the longitudinal connectivity cannot be achieved by conventional solutions (fish passage, fish ladder, bypass, ramp rock etc.) for their positions (in city centers or heights over 2.50 m) do not meet the performance requirements of local upstream migratory fish species. The building costs are affordable as only traditional, inexpensive and locally available materials are used. The platform's slope is designed to be less than the river's serving as an attractant which endows the migration system a high percentage of utility. The operating principle of this system is simple, it follows the basic principles of hydraulics and does not require laborious calculations in sophisticated laboratories that some countries actually do not possess. Maintenance costs are minimal, as any component in the system is positioned and made so that they can be easily replaced in case of any damage.

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