Evaluating the Effect of the Hydrotechnical Works from the Danube’s Caleia Branch on the Spawning Migration of Sturgeons

Tiberius-Marcel Danalache$^{1,2}$, György Deák$^1$, Elena Holban$^1$, Marius Constantin Raischi$^1$, Diana Simona Fronescu$^1$, Carmen Georgeta Nicolae$^2$, Mihai-Alexandru Cristea$^1$

$^1$National Institute for Research and Development in Environmental Protection Bucharest, Romania
$^2$University of Agronomic Sciences and Veterinary Medicine of Bucharest, Romania

E-mail: gyorgy.deak@incdpm.ro

Abstract. Over the years, to maintain navigation along the Danube, the implementation of a series of hydrotechnical works was imposed in order to ensure the continuity of economic activities. Between 2011 and 2014, one such project was built in the vicinity of the county of Braila, on a secondary branch of the Danube - The Caleia branch. The main goal was to redistribute water discharge from the secondary channel to the main branch by construction of a bottom sill. The bottom sill and subsequent discharge redistribution led to hydrodynamic alterations caused by increased water current velocities. These modifications of the hydrodynamic regime may affect the migration of anadromous sturgeon species that swim from the Black Sea to spawn upstream, therefore making the monitoring of the impact paramount. Considering the fact that the anadromous migrating species are internationally protected species, by a series of agreements and conventions, and that the stocks of the species are still in decline, a complex monitoring program was implemented in the affected area. This study presents important information regarding the site utilization during spawning migration and an evaluation of the behavior of sturgeons tagged with ultrasonic transmitters that migrated upstream over the bottom sill. During the monitoring period, the studies show that five sturgeons passed the bottom sill during their upstream migration, swimming against maximum water current velocities of 2.5 m/s.

1. Introduction

Sturgeons are species that have survived the ice age and are currently in continuous decline as a result of anthropogenic interventions to regulate rivers in order to improve navigation. One of the factors that can show a significant negative impact on sturgeon species is represented by hydrotechnical arrangements (construction of dams, hydropower plants, bottom sills for discharge redistribution) on large rivers, which can lead to disruption of migration routes. This disruption has significant effects on migration for spawning in order to regenerate populations naturally. In 1994, about 77% of the rivers in the northern hemisphere underwent various regularization works, with effects on sturgeon
reproduction [1]. Following research studies on the breeding habitats of sturgeon species, it was found that in the Caspian Sea about 91% of these habitats were lost as a result of anthropogenic interventions [2]. However, there were also situations in which sturgeons remained in the area of newly created dams for long periods, during which they laid their eggs, but due to unfavorable conditions the survival rate of larvae was very low, observed in *Acipenser brevirostrum* on the Cooper River from South Carolina [3].

Observing the negative impact that river hydrotechnical works have on sturgeon populations, a series of measures have been implemented worldwide to ensure the support of wild populations: artificial reproduction of sturgeon species in nurseries, creating passageways, arrangement of artificial reproduction areas positioned downstream of the hydrotechnical constructions, etc. Such measures have been developed and implemented on rivers such as the Kuban, Volga, Detroit, Ottawa, but the results have not always been as expected [4].

Regarding the situation in Romania considering the hydrotechnical works of the Danube River, the best known of these and which directly influenced the migration of sturgeon species and even their reproduction is the arrangement of the Iron Gates I and II dams. The implementation of these constructions led to the creation of fish agglomerations in their vicinity in the first years after the constructions completion, a situation that subsequently gradually decreased every year. These agglomerations of fish have been caused by the lack of an alternative through which sturgeons can overcome these obstacles in the migration process [5, 6, 7].

A new project for the hydrotechnical arrangement of the lower course of the Danube was implemented between 2011 and 2014, aiming to redistribute the water discharge from the secondary branch - Caleia on the main branch - Old Danube by constructing a submersible bottom sill, so as to be ensured the minimum depth for maintenance of navigation during drought. Taking into consideration the negative influences that this arrangement of the bottom sill may have on the sturgeon species migration, an extensive sturgeon monitoring project has been launched in the area of interest. Among the objectives of the project was to identify the negative impact on the migration of sturgeon species from the Lower Danube (Sterlet sturgeon, Stellate sturgeon, Russian sturgeon and Beluga sturgeon) in order to identify problems and find alternative solutions to remedy them [8].

The main purpose of the paper is to identify the potential of sturgeon species to overcome by swimming against the water current velocity, the built bottom sill, analysing a number of abiotic factors (level, flow and water velocity).

2. **Experimental**

2.1. **Study area and sturgeon monitoring**

The study area was located on the Old Danube between km 200 and 182, including the Caleia branch on which the construction type bottom sill was carried out, the representation of which can be seen in figure 1.

![Figure 1. 3D representation of the bottom sill on Caleia branch.](image)
In order to monitor the migration of sturgeon species and the influences that the bottom sill can have on the fish movements, in the area of interest were installed 8 monitoring systems - figure 4 - patented by researchers INCDPM Bucharest of type DKMR-01T and DKTB [9, 10].

The DKMR-01T and DKTB monitoring systems have been designed to meet the difficult hydrological conditions encountered on the Danube River, reducing near minimum the risk of receivers loss and thus of the information collected by them [11]. They have the ability to store information transmitted by ultrasonic tags implanted in the abdominal cavity of sturgeon species. Transmitters implanted in sturgeons provide important data on the timing of detections, water temperatures and the swimming depth of the tagged specimens.
2.2. Monitoring of abiotic factors

The abiotic factors that can influence the migration of sturgeon species (level, flow and water velocity) were identified by using single-beam equipment (figures 5-6) with the help of which periodic cross-sections were made in the bottom sill area built on Caleia branch. The results obtained after the data processing were correlated with the periods in which the sturgeons tagged with ultrasonic transmitters transited the area of interest.

3. Results and Discussions

The monitoring systems were fixed downstream and upstream of the bottom sill on the Caleia branch and on the Old Danube at km 200, km 195 and km 182 (figure 4), so that to be able to test several hypotheses: sturgeons mainly use one of the branches to the detriment of the other, sturgeons cannot cross the bottom sill but return to the Old Danube and continue their route upstream, sturgeons cannot cross the bottom sill and return to the sea or sturgeons can cross the bottom sill continuing their route to the breeding sites.

Data obtained from the field, prior to the works completion, indicated that fish use the two branches for migration both upstream and downstream, but without observing a recurrence in the affinity for a particular route [8].

In order to observe and correlate the hydromorphological particularities that will be encountered in the future on the Caleia branch with the biotic factor - sturgeons, this paper analyzes the situation during the spring migration in 2014, when the hydrotechnical construction was completed in proportion of over 95%. The results indicated that a number of 5 sturgeon specimens (2 Beluga and 3 Stellate sturgeons) crossed the bottom sill area by swim against the current, between March and May (table 1).

Table 1 details each specimen in terms of species, the code assigned at tagging, the date when it exceeded the area of hydrotechnical construction and hydrological parameters with a direct influence on migration, resulted from measurements and interpretations performed by the research team. In the case of breeding habitats along the Danube, specimens of the species *Huso huso* - Beluga sturgeon prefer as spawning areas those with depths between 4 - 15 m, reaching even depths of 40 m, but the specialized literature mentions the range 3 - 20 m as being used mainly for reproduction [12, 13].

During migration, sturgeon species most often swim very close to the bottom of the riverbed, but can also be found in the upper layers of the water [12]. The researches conducted analyses the preferred habitat types of sturgeons and gives values of these areas depths, but without specifying a minimum value of the water column height up to which sturgeons can swim.
### Table 1. The values of the abiotic factors at the moment that sturgeons pass over the bottom sill.

| Nr. crt. | Species               | CODE | Date crossing the bottom sill | Water depth [m] | Medium water velocity [m/s] | Water flow [m³/s] |
|----------|-----------------------|------|-------------------------------|-----------------|----------------------------|-----------------|
| 1        | Beluga sturgeon       | 6S21 | 08.03.2014                    | 7.20            | 1.29                       | 3200            |
| 2        | Beluga sturgeon       | 7S1  | 22.04.2014                    | 6.44            | 1.25                       | 2726            |
| 3        | Stellate sturgeon     | 7S25 | 20.05.2014                    | 9.17            | 1.44                       | 4680            |
| 4        | Stellate sturgeon     | 7S30 | 29.04.2014                    | 8.09            | 1.56                       | 3866            |
| 5        | Stellate sturgeon     | 7S15bis | 15.05.2014                    | 8.74            | 1.52                       | 4265            |

In this case, from the data processing regarding the water levels and quotas at which the bottom sill was built, the lowest water depth of 3.24 m was recorded in the banks area in the case of the Beluga specimen code 7S1, and in the center, in the bottom sill area of 6.44 m, which did not present an impediment in passing the hydrotechnical construction. Figure 7 shows the water level reported to the quotas of the hydrotechnical construction for each sturgeon specimen at the time of passing the researched area.

![Figure 7](image.png)

**Figure 7.** Cross section over the bottom sill Caleia Branch.

Most questions arise regarding the water speed and the sturgeon’s possibility to swim against the current. The studies conducted until present indicate different sturgeon swimming potentials. The specialised literature claims that *Acipenser fulvescens*, which has a length of 130 cm, can swim for short periods in a water current with a speed of 180 cm/s [14]. After more research it was found that for the passages construction destined for the species *Acipenser transmontanus* the flow velocities of the water current must be included in the range 0.84 - 2.52 m/s, while for the species *Polyodon spathula*, the water velocity wherewith can face with a sustained effort of more than 200 minutes is 40 cm/s [15, 16]. Thus, it can be concluded that the swimming potential is given by the sturgeon species, their size, the development stage and the environmental conditions in which they live.

For the specimen of the species *Huso huso* - Beluga code 7S1 - figure 8, the average speed calculated on a section from the bottom sill area was 1.25 m/s - figure 8, a situation otherwise common
for the Danube River. Even in the case of Stellate sturgeons, which although have much smaller dimensions, average water velocities of over 1.4 m/s were not an impediment to overcoming the obstacle. Figure 9 shows the water velocity distribution recorded by the measuring device 2 days before the 7S1 pass the obstacle, the water velocity being approximately the same. From the legend it can be seen that the velocity reach the value of 2.5 m/s, but the average does not exceed 1.56 m/s.

![Figure 9. Water velocity distribution on the bottom sill Caleia Branch.](image)

Figure 9. Water velocity distribution on the bottom sill Caleia Branch.

To better exemplify the influence of values over 2 m/s, a histogram was created (figure 10) with the frequency of all velocities recorded by the device when performing the cross section over the hydrotechnical construction. The velocities with the highest frequency, of over 160 occurrences are in the range of 1.6 - 1.8 m/s, and in the case of those over 2 m/s the occurrence frequency is below 40, which is not representing a cause for concern.

![Figure 10. Histogram of velocity bottom sill Caleia Branch.](image)

Figure 10. Histogram of velocity bottom sill Caleia Branch.
Taking into account that sturgeons migrate over distances of tens, even hundreds of kilometers, energy consumption is very high, and the swimming periods will always alternate with the ones of resting or feeding. The conservation instinct and proven adaptability over thousands of years of survival will conduct them on the most convenient routes to spawning sites.

4. Conclusions

Regarding the possibility of sturgeons to pass the bottom sill built on the Caleia branch by swimming against the water current, it was observed that during the spring migration 5 specimens (2 Beluga and 3 Stellate sturgeons) managed this. The minimum water level in the banks area where the Beluga specimen with cod 7S1 passed the bottom sill was 3.24 m. Although the measurements realized with the single beam equipment indicate values of water velocities up to 2.5 m/s, their frequency is very low, the sturgeons having the possibility, in this case, to choose the trajectories with a slower water current. Sturgeon species presents many similarities in terms of anatomy and ecology and yet the particular environmental conditions have created different adaptabilities. On Caleia branch the research will continue for a longer period for collecting and interpreting data in as varied hydrological conditions as possible.

References

[1] Dynesius M and Nilsson C 1994 Fragmentation and flow regulation of river systems in the northern third of the world Science 266 753

[2] Barannikova I, Burtsv I, Vlasenko A, Gershanovich A, Markarov E, Chebanov M 1995 Sturgeon Fisheries in Russia Proceedings of the Second International Symposium on Sturgeons (Kostroma-Moscova: VNIRO Publications) p 124.

[3] Cooke D W and Leach S D 2004 Implications of a migration impediment on shortnose sturgeon spawning North American Journal of Fisheries Management 24 1460

[4] Kerr S J, Davison M J and Funnell E 2010 A review of lake sturgeon habitat requirements and strategies to protect and enhance sturgeon habitat (Fisheries Policy Section, Biodiversity Branch. Ontario Ministry of Natural Resources: Peterborough, Ontario) p 58

[5] Bacalbasa-Dobrovici N 1989 The Danube River and its Fisheries (Dodge, D.P. Ed. in: Proceedings of the International Large River Symposium, Ed.: D.P. Dodge, Can. Publ. Fish. Aquat. Sci. 106) p 455

[6] Bacalbasa-Dobrovici N 1991 Statut des différentes especes d’esturgeons dans le Danube roumain: problemes lies a leur maintenance (In: Acipenserifauna tarii noastre si problema ochotrii lor. Ocrot. naturii si mediului inconjurator, 9 (1)) p 5-21.

[7] Cioclovici A 2004 Study of migratory sturgeon captures in Romanian side of Danube River. Migration of fishes in Romanian Danube River Applied Ecology and Environmental Research 3(1) 73.

[8] National Institute for Research and Development in Environmental Protection Bucharest 2011-2018 Monitoring the environmental impact of the works regarding the improvement of the navigation conditions on the Danube River between Calarasi and Braila, between km 375 and km 175 (monthly and intermediate reports - http://afdj.ro/en/content/romomed).

[9] Brevet DKMR-01T

[10] Brevet DKTB

[11] Deak GY, Raischi M C, Badilici A M, Danalache T, Cristea A, Holban E, Zamfir A, Boboc M G, Matei M, Urîtescu B, Boaja I, Stefan D, Tudor G 2017 Actual status, pressures and preserving perspectives of sturgeon species from Lower Danube River (8th International Symposium on Sturgeon (ISS8): Vienna, Austria)

[12] Reinhart R 2002 Sturgeons in the Danube River Biology, Status Conservation International Association for Danube Research

[13] Hochleithner M and Gessner J 1999 The Sturgeon and Paddlefishes (Acipenseriformes) of the
World: Biology and Aquaculture (AquaTech Publications: Kitzbuhl)

[14] Peake S, Beamish F W H, McKinley R S, Scruton D A and Katopodis C 1997 Relating swimming performance of lake sturgeon (Acipenser fulvescens) to fishway design Canadian Journal of Fisheries and Aquatic Sciences 54 1361

[15] Webber J D, Chun S N, MacColl T R, Mirise L T, Kawabata A, Anderson E K, Cheong T S, Kevvas L, Rotondo M M, Hochgraf K L, Churchwell R and Cech J J 2007 Upstream swimming performance of adult white sturgeon: effects of partial baffles and a ramp Transactions of the American Fisheries Society 136 402

[16] Hoover J J, Killgore K J, Clarke D G, Smith H, Turnage A and Beard J 2005 Paddlefish and sturgeon entrainment by dredging: swimming performance as an indicator of risk (DOER Technical Note. U.S. Army Engineer Research and Development Center: Vicksburg, Mississippi)