Impact of the Lower Danube hydro technical works on sturgeons' migration

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Abstract: - After the construction of the Iron Gates dam in 1972, the sturgeons' population were deeply affected, and in the present, among all European states bordering the Danube, only Romania and Bulgaria still have wild specimens of anadromous sturgeons. Overfishing, poaching, along with other natural factors have already led to the extinction of 2 Danube sturgeon species (*Acipenser sturio and Acipenser nudiventris*) and also the hydro technical works and other anthropic activities have contributed to the degradation of the conservation status of the other 4 species that still survive. In addition, climate change together with anthropic factors can have synergic impact on the sturgeons' migration routes, which can lead to critical migration conditions. In the present, there are big gaps in the knowledge of sturgeons behavior that use the Romanian Danube sector as spawning site, basis that asks for extending the research in this domain. Since 2011, INCDPM (National Institute of Research and Development in Environmental Protection), runs a research project to monitor the impact of the navigating improvement hydro technical works in the Lower Danube, Călărasi – Braila sector (km 375 – km 175) on the aquatic ecosystems. During the time from 2011 to 2015, 315 sturgeon specimens of the 4 species that are reproducing in the Lower Danube sector were captured, ultrasonic marked and released. Considering a possible impacts of the hydro technical works on sturgeons' migration, we analyzed the behavior of sturgeon specimens from 3 different species (*Huso huso, Acipenser guldenstaedtii and Acipenser stellatus*) that crossed the construction sites upon different flow values and water velocities.

Key-Words: - sturgeon, Lower Danube, migration, telemetry, monitoring, hydro technical works

1 Introduction

Sturgeons have appeared on Earth 200 million years ago, somewhere at the end of the Triassic, being the oldest species of Actinopterygii. Over time sturgeon species have undergone few morphological changes, their development has been very slow, hence the name "living fossils" [1]. Survival for a period so great, is partly explained by tolerance to different temperature and salinity, the lack of predators is due their large dimensions of the specimens and abundance of feed specific to the benthic environment in which they are spending the most of their lives. However, lately sturgeon species from around the world registered massive losses [8]. This specimens decline may be the result of hydro technical constructions, overfishing and pollution of aquatic environment, with a direct impact on migration and reproduction of sturgeon. The main factor is the mankind socio-economic development that led to overall environmental degradation, having as significant indicators: pollution, overexploitation of natural resources and changing the parameters of hydro morphological elements. All these synergistic activities have had and still have a dramatic impact on the health of aquatic ecosystems resulting in serious, often irreversible losses. Most aquatic ecosystems have the ability to cope with external stresses, however, lately received signals (massive loss of biodiversity, the decline of fish stocks), show that their natural resistance threshold was exceeded [5].

Sturgeons are found only in the Northern Hemisphere. Half of these species are found in Europe, one third in North America and the rest in East Asia and Siberia [2]. They are characterized by important intraspecific differences that depend on the geographical conditions of the habitat in which they live. For example, depending on the species and the habitat of specimens, puberty occurs at different ages and reproduction is not achieved every year [2]. Sturgeon migration is one of the most important adaptations that contribute to the broadening and multiplication of specimens, leading to the biological advancement of the species.

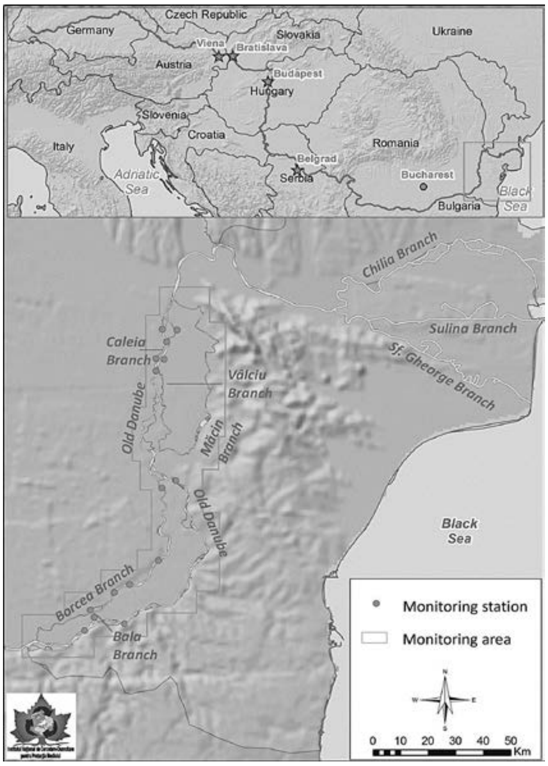
Anadromous species are those that support transition from one environment to another, switching from seas to large rivers, and back, therefore the possibility of adjusting their organism to the pressure supported due to environmental change is a decisive factor in the migration process. Factors influencing migration are water currents, which, in most cases, dictate the orientation and distance traveled (especially for juveniles) and species preference / specimen regarding the spawning site [2]. Sturgeon migration route and even their final destination, either on departure or return, are in constant dependence on the aquatic environment in which it migrates. Shifting environmental conditions makes important changes in the pathway that the specimen crosses during its migration. The change in environmental conditions is dictated on one hand by climatic factors (temperature, wind, precipitation) and, on the other hand on transformation results from hydrological processes [6]. Studies and current evidence listed in the IUCN Red List, presenting the most complete inventory of the conservation status of animals and plants species, being the best indicator of global biodiversity shows that sturgeon species that are found on the Romanian territory are in the following situation:

- Beluga Sturgeon (*Huso huso*), critically endangered
- Russian Sturgeon (*Acipenser gueldenstaedtii*) , critically endangered
- Stellate Sturgeon (*Acipenser stellatus*) - Critically endangered
- Sterlet Sturgeon (*Acipenser ruthenus*) - Vulnerable

Hydrotechnical constructions, that had the effect of modifying the hydromorphologics of riverbeds, habitat fragmentation, loss of adjacent wetlands, deltas and estuaries damage, are some of the main causes of the decline of the ichthyofauna stocks. According to the World Conservation Union, 20% of freshwater fish species are endangered or already disappeared. The global situation observed is that all species of sturgeon are in critical condition, according to IUCN Red List, this reflects the spawning habitat destruction and the access pathways to them through the construction of dams and hydrotechnical works on running water courses. On rivers where dams are present, lakes or other water catchments, near the sea, mostly due to changing of hydrological parameters, there is a danger of reducing the flow of water in such manner as to limit the migration. CITES (1973) has as main goal the preservation of endangered species and protection of ecosystems of which they are part of. So, the application of that regulation is seeking to develop recovery plans for endangered species, such as sturgeons [7]. But in order to develop strategies for the recovery and conservation of critically endangered populations of sturgeon in the Lower Danube specimens should be monitored in order to identify areas for feeding, wintering and spawning; this action is seen as a major importance to take the most effective measures for the conservation of habitats.

2 Problem Formulation

The Calarasi-Braila, Danube sector, (km 375 - km 175), analyzed in this paper, it is the route of migration of sturgeon species and at the same time is an important commercial shipping route, linking the Danube River, the Maritime Danube and the waterway Danube-Black Sea (Figure 1). In order to improve navigation conditions on the Danube, in the period 2011-2015 in this sector were constructed hydro technical works, respectively, a bottom sill on the Bala branch and routing dams on the Old Danube. Increased water flow on the Old Danube aimed to facilitate the commercial navigation and shorten the navigable route to the Black Sea with over 100 km.



Fig, 1 Geospatial representation of the monitored area and the emplacement of the sturgeon monitoring systems [3].

INCDPM (National Institute for Research and Development of Environmental Protection) based on the project "*Monitoring the environmental* *impact of works to improve navigation conditions on the Danube between Calarasi and Braila, km 375 - km 175*", since 2011 and until the present, has conducted monitoring, measurements, investigations and sampling across the sector of the Danube, Calarasi - Braila. The main objective in this period was to monitor the related construction area, especially in terms of impact on the sturgeon migration. Knowing the conservation status of critically endangered sturgeon in the Lower Danube, river blockages and negative effects on migratory aquatic species, monitoring was done with the utmost care using the latest techniques and methods up to date [4] in order to identify win-win solutions allowing both improving navigation conditions and environmental protection.

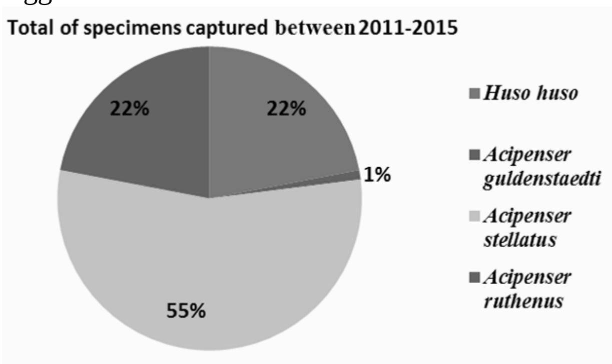
3 Problem Solution

It is now clear that there are big gaps in the knowledge related to the behavior of sturgeon reproduction area that use the Romanian Danube sector, highlighting the need to extend research in this area. INCDPM experts intensively monitored areas upstream and downstream of the bottom sill assembly line and concluded from processing the recorded data, the sturgeons capacity of moving against high flow velocities of water. The monitoring of the 4 sturgeon species in the Lower Danube was performed using acoustic telemetry, by inserting ultrasonic taggs in the captured specimens in the April 2011-December 2015 timeline. In order to continue monitoring under the hydrological difficult conditions of the Danube, INCDPM researchers have developed and patented two monitoring systems (fixed type DKTB and floating type DKMR-01T) which uses ultrasonic signals interception equipment via telemetry [3]. Location areas of the monitoring were determined after bathymetry campaigns. With a vessel equipped with a multibeam sonar were determined morphology sections of the riverbed, upstream and downstream of the bottom sill constructed on the Bala branch, by the acquiring measurements from one end to the other of the river bed lengths of 600 m. The multibeam measurement result is a 3D representation of the riverbed that allowed the identification of areas that allows the range of ultrasonic receivers to be used at maximum capacity.

The behavior of sturgeon in terms of moving against the high current, was analysed using data provided by the monitoring systems installed in situ (Figure 1) and by aquiring bathymetric measurements with ADCP (Acoustic Doppler Current Profiler) which provides important data on the water velocity and configuration of the riverbed in the the area of interest.

3.1 Capturing and sturgeon ultrasonic tagging

Between 2011 - 2015 were captured, tagged and released 315 specimens from the 4 sturgeon species that spawn on the lower Danube. The Figure 2 shows the total catches by species in every year of conducted research. From the data obtained it is observed that the most endangered species is Acipenser guldenstaedti, across the period of the research study only 4 specimens were captured and tagged.



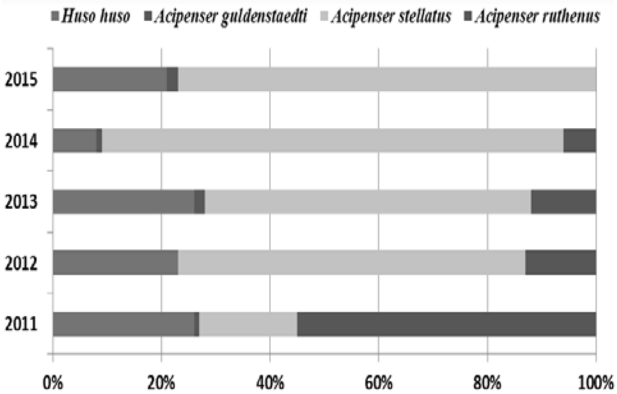


Fig. 2, Total captures achieved during the period april 2011 - december 2015

Ultrasonic sturgeon tagging was done through a minimally invasive surgery, directly into the Danube water, thus avoiding the stress of transportation to marking points. The suture was made with resorbable surgical thread, and to prevent post-operative infections until cicatrisation, it has been used a special gel that ensure hermetic area closure, and velocities up the closing of the incision (figure.3). Every ultrasonic tagging was performed in a restraining tube provided with slots for the free circulation and oxygenation of the water.

Fig. 3, Procedure for sturgeon ultrasonic tagging and release

The operation was carried out by people with training courses in this regard, closely supervised by a veterinary expert. All the sturgeons were tagged to the dorsal fin with an external "spaghetti-antipoaching" tag. (Figure 5) This tag allows the identification the specimen at a future recapture and warns of fishermen that the specimen is part of a scientific study. (fig 3).

Fig, 4
Ultrasonic tag

Fig. 5,
Spaghetti-antipoaching external tag

3.2 Sturgeon migration monitoring results

After processing the data recorded by the monitoring equipment DKMR-01 T and DKTB placed in-situ according to figure 1, we could identify the behavior of sturgeon in situations involving movement against the water high current and could make a database of unique importance in Europe, on migration routes and spawning habitats in the Lower Danube sturgeon. The most unexpected phenomenon occurred in the period of the project and that negatively influenced the results of the research was poaching. Manifested in various forms, poaching contributed to the loss of around 66% of tagged specimens during 2011-2015 (Table 1)

Specimens	number	%
Poaching	**208**	**66**
Recordings	107	44
Total Sturgeons	315	100

Tabel 1 Centralized of poached specimens

According to centralizer presented, more than half the sturgeons captured, tagged and released were poached, results are assessed on the basis of data obtained from monitoring systems installed in situ as shown in Figure 1. An example of identifying the phenomenon of poaching is presented in Figure 6, as recorded at the DKMR-01T station located on Borcea branch, km 3, were observed multiple detections that indicated the presence for a long period and at the same depth of a mature specimen of the species *Acipenser stellatus* tagged in the spring of 2014 , which was not usual behavior for the fish. In the event shown, most likely the poachers captured the specimen, they removed the ultrasonic tag (Figure 4) and threw it in the Danube water. The emergence of poaching was confirmed on the branch of St. George near the Danube spills in the Black Sea, where the monitoring station located in the area recorded multiple detections in the period March-May 2016 indicating a similar situation to the one shown above. Moreover, in the period of the research studies of sturgeon migration were found several such cases of poaching.

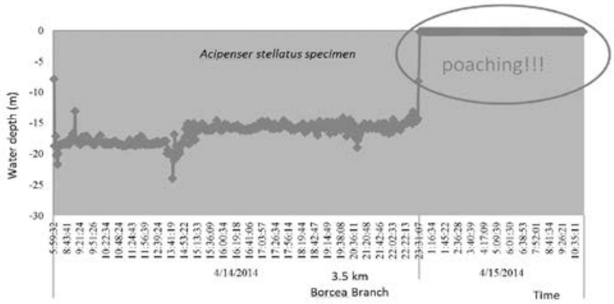


Fig.6, Interpretation of the data recorded by the monitoring station DKMR 01 T and confirming the phenomenon of poaching

Excluding problems due to poaching, sturgeon migration monitoring confirmed that sturgeon migrate upstream branch Bala to existing spawning habitats until the Iron Gates. Of the 315 specimens tagged to the end of December 2015 only 23 specimens about 7% have migrated upstream, or Bala, either on the Old Danube. Distribution in fig 7. shows that 14 of the 23 specimens went upstream on the branch Bala and only 9 on the Old Danube and that given that in the 2012-2015 were conducted hydro technical works to build the bottom sill.

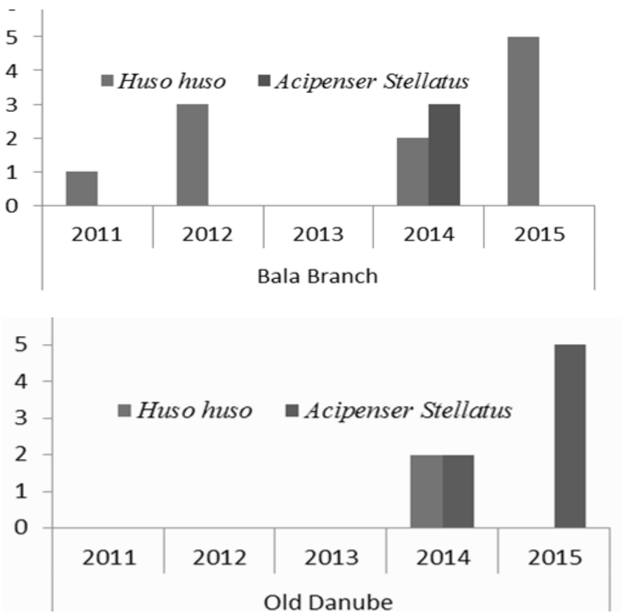


Fig 7, The distribution of sturgeon specimens in the Danube branches

INCDPM experts' analysis based on the informational volume until the present, concluded that constructing the bottom sill at the moment does not adversely affect the sturgeon migration on Bala branch compared to the Old Danube.

3.3 Interpretation of sturgeon movement against high velocities of water with the DKMR- 01T monitoring systems and Acoustic Doppler Current Profiler bathymetry measurements

During the autumn migration, November 2015 when the bottom sill construction was in a final stage, 3 of the tagged Huso Huso specimens migrated upstream passing the bottom sill. To determine water flow rates and the appreciation of the possibility of movement of sturgeon in certain hydrological situations the research team conducted longitudinal bathymetric measurements over the bottom sill, near the banks and on the center of the Bala branch. Figure 8 shows the distribution of the sections and of the DKMR-01T monitoring systems locations through GPS coordinates. From the variation of water velocities depending on depth in the longitudinal section (Fig. 9), it is noted that they exceed 2 m/s, peaking at values of 3 m/s over the crest of the bottom sill, which could be a problem for the advancement of sturgeons. Following interpretations in Fig 9 is seen that the highest velocities are in areas where flow section shrinks due to irregular geometry of the bottom sill. In the case of SLCB1 and SLCB2 the velocities are of over 2 m/s and are maintained over a longer distance than SLCB3.

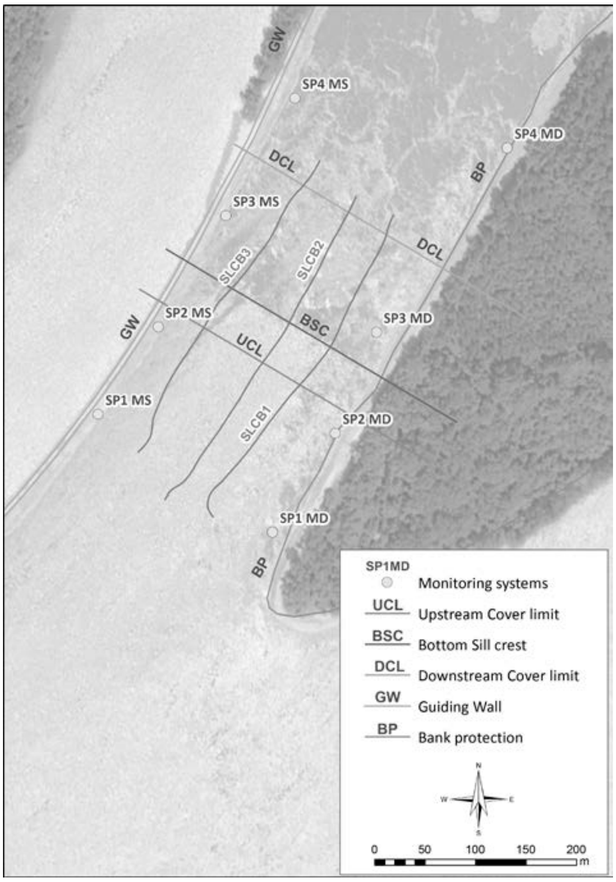


Fig. 8, Distribution of longitudinal sections and of the DKMR-01T monitorin systems.

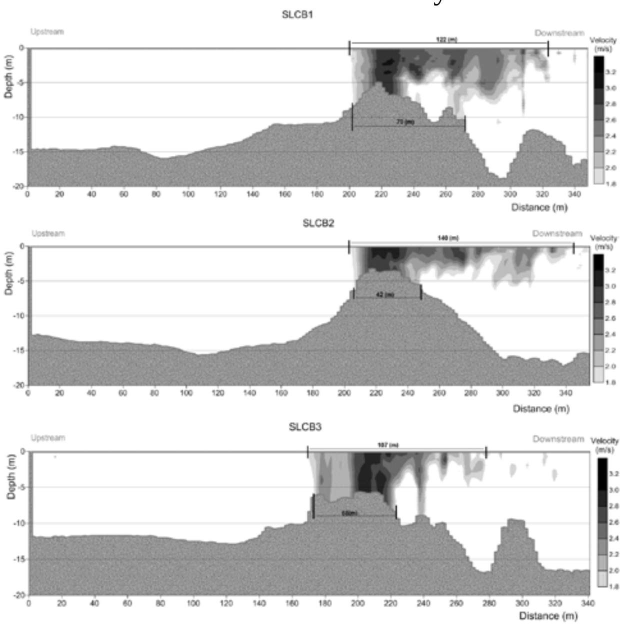


Fig 9, Velocities distribution in longitudinal section

Monitoring stations placed in situ (Figure 8) also registered that sturgeons prefer to transit through the left side of the bottom sill, thus avoiding movement against high velocities of water. For water velocities interpretation also were performed cross-sections in front of 4 detection gates, the highest velocity being recorded in front of the gate SP3 situated downstream of the bottom sill (Figure 10). From the histogram interpretation of section SP3 is observed that on the surface velocities exceeded 2 m/s. With increasing water depth and due to uneven geometry of the riverbed, water velocity decreases which allowed sturgeon slipping among large rocks that constitutes the bottom sill.

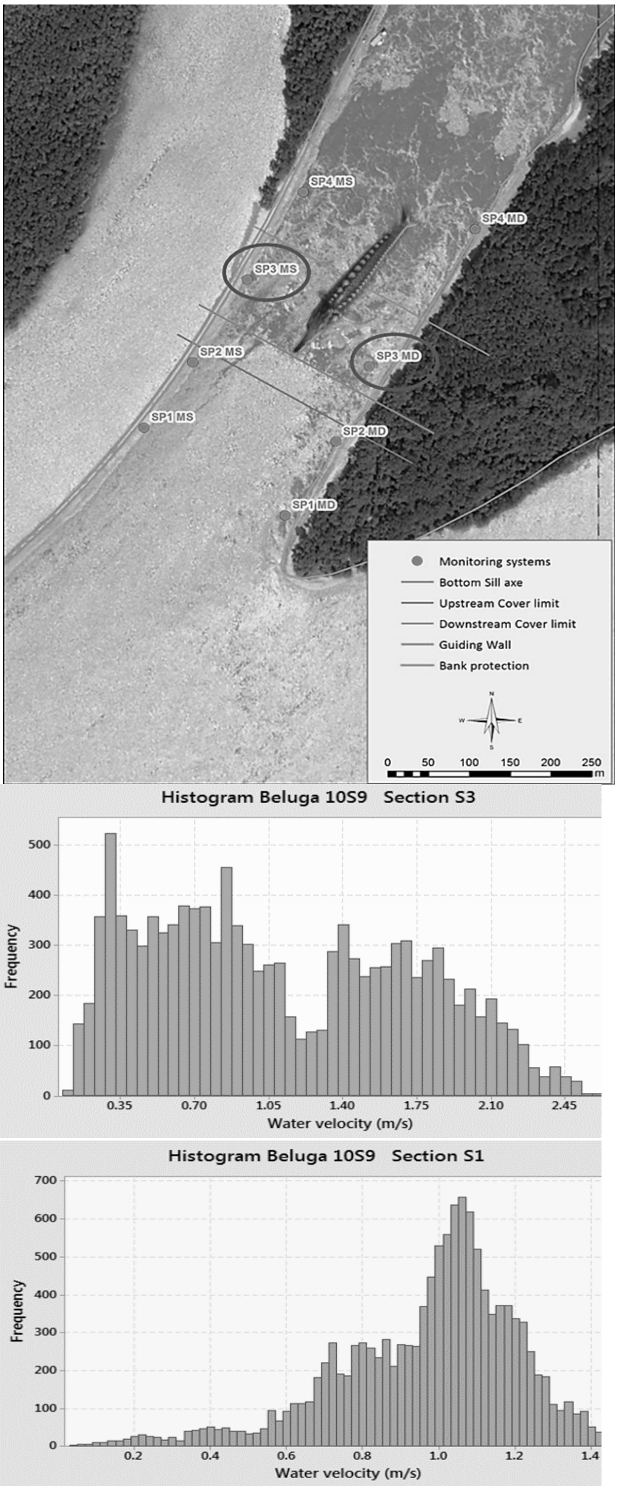


Fig. 10, Velocity distribution in cross sections

After surpassing the bottom sill against the water current section SP1 velocities drop considerably, the most common recorded velocities is in the range of 1-1.2 m/s

4 Conclusion

In the period 2011-2015 were tagged, caught and released on the Lower Danube, 315 specimens of 4 sturgeon species in order to identify the potential impact of hydrotechnic works (especially setting a bottom sill) carried on the Bala branch, on sturgeon migration. After processing the data recorded by the monitoring systems DKMR-01T and DKTB placed in situ, it was able to achieve a unique database at a European level concerning sturgeon migration routes and spawning habitats in the Lower Danube

Research has indicated that sturgeons migrated both Bala branch and Old Danube in the period of the hydro technical works. When sturgeon passed over the bottom sill built on Bala branch, water rates exceeded 3 m/s in some areas such as the the surface crest of the bottom sill. Frequent velocities recorded in two cross sections from the the bottom sill showed an enhanced dynamics with large differences from one section to another. Section SP3, because it is upstream of the bottom sill axis it is characterized by the values of velocities over 2 m / s but with a rather low frequency of presence. In this section prevails velocities between 0.3-1.05 m/s.

Depending on the velocities variation by depth in the longitudinal sections (Figure 9), it is noted that they exceed 2 m/s, peaking at values of 3m / s over the crest of the bottom sill. After interpretations of water velocity variation in the two cross sections in conjunction with the values obtained in longitudinal sections, it can be appreciated that the highest velocities are in the axis of the bottom sill mainly in the centre and on the right bank; Monitoring stations DKMR-01 T also had several detections of sturgeon specimens on the left bank.

According to data obtained, it can be stated that at present hydro technical works done in the branch Bala does not prevent migration of sturgeon upstream of the bottom sill, but monitoring should continue in post construction for a period of minimum 5 years in order to know the movement behavior of sturgeon in several hydrological situations (an example would be reduced flows in periods of drought)

Regarding the conservation status of sturgeon species in the Lower Danube, we can conclude that *Acipenser guldenstaedtii* species are in danger of extinction (Fig. 1). In the period of the project, were captured only 4 specimens, about 1% of all specimens. One reason for degradation of the conservation status of this species can be poaching.

Although commercial fishing is banned by law since 2006, poaching occurs extensively on sturgeon, evidence of the fact that 66% of specimens monitored in this project were poached.

In Romania is likely to be represented by only 4 of the 6 previously existing sturgeon species in the Danube. Of all the European countries bordering the Danube, Romania and Bulgaria have in the territorial waters the only wild anadromous sturgeon specimens, from here one can be highlighted the importance of achieving rapid protection measures and the recovery of critically endangered species. The sturgeon monitoring in order to determine the routes of migration, spawning habitats, knowing the behavior of specimens in certain situations hydrological, in conjunction with the information and awareness of the population and the authorities about the importance of protecting the aquatic biodiversity, represents measures to be implemented urgently to improve the conservation status of these species in danger of extinction.

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