The impact of anthropogenic pressures on sturgeon migration in the Lower Danube

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Abstract. The Black Sea sturgeons are anadromous fish species [1], which migrate upstream on the Danube River for breeding. The distance traveled in the migration process varies depending on each species, from tens to hundreds of kilometers [2]. After breeding, the anadromous sturgeons return to the Black Sea and go back to the Danube after a time that varies depending on the species between 3 and 5 years [3]. All sturgeon species that migrate in the Danube basin are on the IUCN Red List of Threatened Species [4]. Considering that sturgeon migration is a condition of the existence of species [5], INCDP developed in 2011-2017 extensive research studies of their behavior. Using ultrasonic telemetry, unique information volumes have been obtained on the behavior during sturgeon migration in different hydrodynamic conditions and under the pressures caused by anthropogenic activities. The intensity of poaching was also analyzed, resulting in that this pressure represents a real threat to the existence of sturgeon species. Over 70% of the total specimens monitored in research studies, developed by INCDP during the over 7 years of research, were poached. The research was conducted in full compliance with the provisions of the EU Biodiversity Strategy for 2030 [6], which aims to conserve endangered habitats and species, including by reducing and eliminating by-catches.

1. Introduction

In-depth studies identify in Romania the presence of only 4 species of wild sturgeon populations, out of the 6 previously existing in the Danube [7]. Of all the EU member states bordering the Danube, only Romania and Bulgaria still have in the territorial waters specimens of wild anadromous sturgeons [8]. According to Order no. 84/1302 of April 24, 2012, on the measures for the restoration and conservation of sturgeon populations in natural fish habitats and the development of sturgeon aquaculture in Romania, the conservation status of sturgeon species in the lower Danube basin is as follows:

- beluga (*Huso huso*) - critically endangered species
• common sturgeon (Acipenser gueldenstaedtii) - critically endangered species
• stellate sturgeon (Acipenser stellatus) - critically endangered species
• starlet (Acipenser ruthenus) - vulnerable species [9].

Huso huso, Acipenser gueldenstaedtii and Acipenser stellatus are anadromous migratory species, whose migration is an essential condition for the natural perpetuation of the species. To ensure migration corridors, the National Institute for Research and Development in Environmental Protection (INCDPM) coordinated in 2011-2017 the most complex monitoring project, carried out on the section km 375 ÷ km 175 (between Călărași and Brăila) [11], continuing with other areas between the Iron Gates dam and the Black Sea. More than 300 sturgeon sturgeons were captured and marked with ultrasonic transmitters, subsequently released and monitored by ultrasonic telemetry.

The monitoring action was imposed as necessary at the beginning of 2011 because on the Danube section Călărași - Brăila it was expected to carry out the hydrotechnical work - new bottom sill (NBS) on the Bala branch at km 9.7. Taking into account the poor conservation status of sturgeon species and the fact that any intervention on the flow section involves changes in the hydrodynamic parameters of the water, from the beginning of construction it was considered important to assess the impact on migration and reproduction of these endangered species. The INCDPM team investigated in detail the behavior of sturgeons while moving upstream, over the NBS on the Bala branch.

Simultaneously with the intensive monitoring carried out in the area of the hydrotechnical works on the Bala branch, in the period 2011-2017, fixed and floating monitoring stations were placed on a 600 km route along the Danube, including the branches through which the river flows into the Black Sea. The monitoring action aimed to identify the general behavior and migration routes of sturgeons, respectively the identification of anthropogenic pressures to which they may be subjected. The paper presents the results regarding the anthropogenic impact on the sturgeon population marked with ultrasonic transmitters and monitored on the migration route from the Black Sea to the downstream of the Iron Gates dam and back. It also presents the impact of poaching on sturgeons, with the main purpose of providing important data to support the sustainable management of populations and habitats of sturgeon species in the Lower Danube. Romania’s Sustainable Development Strategy 2030 [12], harmonized with the UN 2030 Agenda [13], sets one of the 2030 targets, for SDG 15 “Life on Land”, the conservation and protection of biodiversity and sensitive habitats as part of the national and European natural heritage.

2. Experimental

The analysis of migratory sturgeons from the Lower Danube was performed with the data provided by the wild specimens captured. The scientific fishing took place in the Danube area, on the sections related to the Borcea branch and Caleia branch, performed by authorized fishermen. Thus, between May 2011 and December 2017, 300 specimens of Huso huso, Acipenser stellatus, and Acipenser gueldenstaedtii were captured. For long-term monitoring, sturgeon specimens were ultrasonically marked [14] and monitored for at least one migration cycle. After the ultrasonic transmitters implantation and specimens release in the Danube, the sturgeons were monitored by ultrasonic telemetry, with monitoring stations developed and patented by INCDPM, and also with the VR100 mobile receiver.
2.1. Location of the study area

Monitoring stations were placed along the Danube on a route of 633 km that includes the branches which reach the Black Sea, in order to collect a volume of information with a high level of confidence. This informational volume helps evaluate the behavior of sturgeons, and identify migration routes and breeding areas. The location of the monitoring stations, for receiving ultrasonic signals emitted by the transmitters implanted in the specimens, was chosen to cover the most important routes of sturgeon movement in the Lower Danube sector. The number of monitoring points was established and mapped by GPS. Between km 633 of the Danube and its flow into the Black Sea, 41 monitoring points were established between 2011 and 2017 (figure 1).

![Figure 1. Location of the monitoring systems (2016).](image)

For areas with a flat riverbed, which enables the continuous reception of signals, a single monitoring station was used. For uneven areas gate-type monitoring systems were used, consisting of several stations located so as to ensure the reception of signals emitted by the marks implanted in the sturgeon specimens, on the entire cross-section of the riverbed. To assess the specific behavior of sturgeons during the passage over NBS located on Bala branch at km 9.7, 15 monitoring stations monitoring were positioned, patented by INCDPM type DKMR and DKTB, located every 50 m on both sides.

2.2. Measurement and monitoring techniques

In the period 2011-2017, in situ measurements of hydrodynamic parameters and bathymetric determinations were taken, using single and multi-beam equipment to periodically map the dynamics of the riverbed and the distribution of water flow velocities.

For the monitoring of sturgeons, fixed and mobile monitoring stations were used to receive the ultrasonic signals of the transmitters implanted in the specimens [15]. For detailed investigations or in cases when the sturgeons were outside the station detection area the Vemco VR100 mobile monitoring receiver was used to determine the exact depth and behavior of sturgeons. Figure 2 shows the equipment used in field activities.
3. Results and discussions

3.1. Analysis of the influence of a submerged hydrotechnical construction on sturgeon migration

One of the important anthropogenic factors that could influence the movement of sturgeons in the Lower Danube is NBS on the Bala branch at km 9.7, upstream of the old bottom sill (OBS) made in the 1980s [16]. To assess the degree of influence of NBS, the area between Izvoarele, Bala branch km 9.5, and Old Danube km 342 was monitored. The hydrodynamic and hydromorphological conditions in the area were analyzed before, during, and after the completion of NBS construction. Figure 3 shows the morphologies of the riverbed on the Bala branch area before and after the NBS construction.
Figure 3. Morphological representation of the riverbed on Bala branch.

The processing of data obtained by *in situ* bathymetric measurements for the two situations – before (2013) and after (2016) NBS construction – highlighted the hydromorphological changes that occurred in the Bala branch, after NBS construction. It is noted that there is a historical impact caused by OBS, located 600 m away from the bifurcation of the Bala branch - Old Danube, considered until June 2013 as part of the morphology of the Bala branch bed. With the beginning of construction, NBS began to change the morphology of the riverbed and change the hydrodynamic regime in the area [17]. These changes and the loss of control during the execution of NBS have led to the reactivation of the impact of OBS. Thus currently, it cannot only be talked about the impact of a single bottom threshold but a complex of two submerged obstacles, namely NBS and OBS. Following the processing of bathymetric measurements, before and after the construction of NBS [18], it was found that the hydrodynamic and hydromorphological variations of the Bala branch sections are complex, with changes over time, which require further monitoring of the area.

In the period 2011-2017, from the data recorded by the monitoring stations located in the area of interest, 30 specimens of marked sturgeons were identified, which moved upstream of the Izvoarele area. Out of these, 8 moved upstream on the Old Danube, the remaining 22 preferring the Bala branch. A concrete example is the passage of two specimens of *Huso huso* (H1 and H2) over the complex formed by two submerged obstacles, thus proving that in this case at the elevations of the crowns of the NBS on the Bala branch there is still no risk of interrupting the sturgeon migration route. Figure 4 shows the results of the hydrodynamic analysis during the passage of the H1 and H2 over the complex formed by two submerged obstacles.
Water level (m) | Velocities histogram | NBS - crowning bathymetry
--- | --- | ---
12.3 | ![Histogram for water level 12.3 m](image1.png) | ![Bathymetry for NBS area](image2.png)
8.84 | ![Histogram for water level 8.84 m](image3.png) | 

Figure 4. Hydrodynamics in the NBS area for different water level conditions, relative to BSS elevation.

The two specimens passed NBS in different hydrodynamic conditions, at a water level registered at Izvoarele and compared to the Black Sea / Sulina (BSS) level of 12.3 m for H1 and 8.84 m for H2.

H1 arrived in the NBS area on 03.03.2016, oscillating on the Bala branch with several attempts to cross the thresholds within 10 days. At the moment of crossing upstream of the Bala branch, on 13.03.2016, the speeds in the cross-sections registered a maximum of 3.2 m/s, in the central area of the NBS crown. According to the presented histogram, the most frequent speeds in the section were between 1.25 and 2.00 m/s.

H2 arrived in the NBS area on 23.04.2016, managing to pass upstream on the same day, at a water level of 8.84 m (registered at Izvoarele and related to the BBS level). Unlike H1, H2 managed to cross the threshold in hydrodynamic conditions with much higher flow velocities, caused by the water level drop of over 3.46 m.

In conclusion, it is noted that the hydrotechnical works carried out on the Bala branch involved morphological changes in the section of the riverbed which led to the increase of water velocities in the section. It is observed that the sturgeons have the capacity to cross upstream NBS, for similar morphological conditions as in 2016 and for a water level between 12.30 m and 8.84 m (registered at Izvoarele and related to the BSS level). It can be stated that, at present, NBS does not have a significant impact on the possibility of sturgeon migration, but the risk of changes in the investigated area over time, leading to the interruption of sturgeon migration routes, is not excluded.
3.2. Impact of poaching on the research results

During the monitoring of ultrasonically marked sturgeons, poaching negatively influenced the research results. Manifested in various forms, poaching has contributed to the loss of over 70% of all marked specimens. Thus, only 76 specimens out of the 300 marked (belonging to the 3 species of anadromous sturgeons from the Lower Danube) survived until the end of 2017.

Table 1 shows the impact of poaching in relation to the number of catches. The control panel includes specimens that were not detected or were initially detected, and subsequently had no detection (it is excluded that they pass without being detected by receivers) and those whose marks were identified in the riverbed in different locations.

**Table 1. The percentage of monitored sturgeons.**

| Total sturgeons | Poached | Likely poached | Monitored |
|-----------------|---------|----------------|-----------|
| Number of specimens | 106    | 118            | 76        |
| Percentage (%)   | 35      | 40             | 25        |

On the studied Danube sector, the monitoring stations were placed with regards to the morphology of the riverbed, so as to ensure monitoring from one side to another, and high efficiency in detecting ultrasonic signals emitted by the transmitters implanted in sturgeon specimens. From the number of specimens presented in Table 1, some were classified as likely poached. These were never detected after release on the monitored sector, so the probability of poaching is very high.

Next, the number of monitored specimens in each research year and the number of those that can be detected until the expiration of the battery life of the brands implanted in the specimens of the species *Huso huso* and *Acipenser stellatus* (see Figure 5) are presented. The analysis took into account both the real situation, given the battery life, and the possibility of poaching, as well as the situation in which poaching was excluded.

![Figure 5. Monitored specimen number of *Huso huso* and *Acipenser stellatus.*](image-url)
Figure 5 shows that in 2017 the highest number of *Huso huso* should have been monitored, 97. However, the real situation was greatly influenced by poaching. Therefore, only 40% of the specimens were monitored in 2017. For *Acipenser stellatus*, 2015 should have been the year with the highest number of monitored specimens, 138, but even in this case, due to poaching, only 30% of the marked specimens were monitored.

The large number of specimens estimated as poached represents a !!! warning signal, which calls for firm measures to stop the danger of extinction which anadromous fish species face when migrating from the Black Sea on the Danube River upstream for breeding. It is crucial to intensify the catch monitoring actions, in order to establish databases for each threatened species. This is in line with the EU Biodiversity Strategy, and the comprehensive research conducted by INCDPM resulted in a unique current database. Analyzing the anthropogenic pressures that can interrupt the migration route of anadromous sturgeons, it can be concluded that 29% of the specimens marked with ultrasonic transmitters have successfully overcome the complex consisting of two submerged obstacles on the Bala branch.

4. Conclusions

The hydrotechnical works carried out on the Bala branch resulted in morphological changes in the riverbed section and also in the increase of water velocity. However, 22 sturgeons from the total catches ultrasonically marked during 2011 – 2017, moved on the Bala branch during migration. 73% of the specimens moved on the Bala branch and only 27% on the Old Danube. Thus, it can be concluded that sturgeons have the ability to move upstream against high water currents and that the complex hydrotechnical works consisting of two submerged obstacles NBS and OBS, in the current conditions, do not have a significant negative impact on the migration process. Furthermore, it is very important to continue to monitor the morphology of the area, in order to identify changes that could negatively impact aquatic ecosystems. Sturgeon species are generally adaptable to changing environmental conditions, but not to anthropogenic pressures with a direct impact on them, such as poaching. Analyzing the anthropogenic pressures that can interrupt the migration route of anadromous sturgeons, it can be concluded that 29% of the specimens marked with ultrasonic transmitter survived and successfully overcame the complex of two submerged obstacles on the Bala branch. If in the case of submerged hydroconstructions, the results of the application of current legislation can be quantified by identifying and applying those "win-win" solutions to ensure the protection of biodiversity, the same cannot be said about poaching. Although there is legislation that prohibits the capture of sturgeon specimens since 2006 [9], poaching is still intensely practiced along the Lower Danube. As presented in the paper, more than 70% of the sturgeon captured, marked and released during the INCDPM research on the Old Danube, were most likely poached. To stop this, appropriate measures must be identified to control the phenomenon, which until 2006 was called “overfishing”. At the European level, the aim is to eliminate “by-catches” by 2030, while at the national level the goals are the conservation of sensitive habitats and biodiversity, and the effective control of poaching.

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