The Preference of Anadromous Sturgeon Species Regarding Temperature and Depth Parameters During Spawning Migration in The Lower Danube

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Abstract. Anadromous sturgeon populations in the Lower Danube are in severe decline, and this is due to a combination of anthropogenic and natural factors that have a major impact on the life cycle of the species. Stationary swimming parameters, namely water temperature and depth, represent the starting point for developing the best procedures to identify breeding habitats and subsequently develop the best conservation measures in the context of anthropogenic impacts and climate change. According to current data, *Acipenser gueldenstaedtii* is the most endangered species, as it is the rarest species captured through scientific fishing and has highest temperature sensitivity of the three taxa studied.

1 Introduction

Globally, sturgeon populations have undergone massive stock declines in recent times [1]. mainly due to the socioeconomic development of human communities, which has resulted in the degradation of environmental components over time.

These species have been and continue to be threatened by multiple factors, including overfishing and poaching, hydrotechnical constructions and alterations of the aquatic environment, climate change and pollution. These anthropogenic and natural activities have resulted in the deterioration of the fresh water environment and have a major impact on biodiversity, causing significant and often irreversible losses, and the scientific community warns that the resistance threshold of aquatic ecosystems has already been exceeded [2].

The latest IUCN-SSG (International Union for the Conservation of Nature – Sturgeon Specialist Group) global assessment, published on 21 July 2022, reveals that anadromous sturgeon species currently present in the Lower Danube (Acipenser stellatus, Huso huso, and

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Acipenser gueldenstaedtii) retain their "Critically Endangered" status, with a steady trend of declining populations [3].

The distribution range of the three anadromous sturgeon species has massively decreased relative to its historical extent [3]:

- *Acipenser stellatus* (the stellate sturgeon) is currently present with breeding populations only in the Black Sea and the Caspian Sea, compared to the past situation where it was also present in the Azov, Aegean and Adriatic Seas;
- *Acipenser gueldenstaedti* (the russian sturgeon) inhabited the Black, Caspian, and Azov Seas, as well as their tributaries. The species is now thought to be extinct in the Azov Sea basin. Regarding the Danube region, there are currently only isolated breeding population segments, with the last confirmed natural reproduction reported in 2006 at the national level.
- *Huso huso* (beluga sturgeon) was historically present in the Black Sea, the Caspian Sea, the Sea of Azov (extinct since the end of the 20th century), and the Adriatic Sea (extinct since the 1970s). Today, the only reproducing populations globally exist in the Lower Danube.

Monitoring the migration behaviour and specific breeding habitats of sturgeon species is a priority for the scientific community in Romania, given the critical condition of the stocks and the extent of the cumulative impact of anthropogenic and climatic factors.

2 Materials and methods

From 2011 to 2018, INCDPM coordinated the largest research projects on the subject, between Călărași and Brăila (on the section km 375 - km 157) [4], and is currently extending the monitoring area on 1500 km of the Danube, from the Black Sea to Baziaș (Fig. 1), as a result of the Danube Region Water Lighthouse Action - DALIA, PN 23 31 02 01 SturHabCons and PNNR, Pillar I "Green Transition", Component 2 "Forests and biodiversity protection", Investment 4. 4- Implementation of a wild sturgeon monitoring system along the Lower Danube [6,7,8].

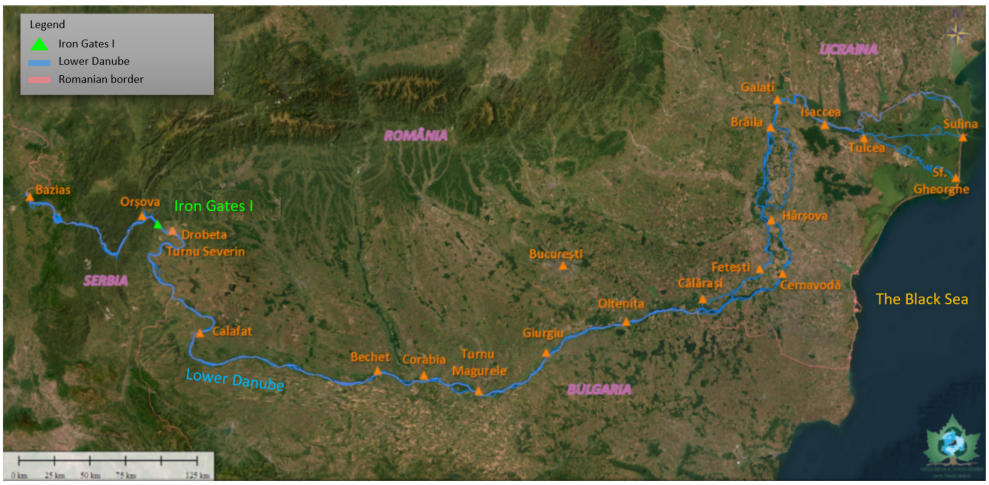

Fig. 1. The extended migration behavior and reproduction habitats monitoring area.

From 2011 to 2022, 631 individuals were continuously captured, tagged with ultrasonic

transmitters, and released, with the condition that the number of scientific fishing days depended on obtaining authorizations. Nonetheless, specimen monitoring occurred throughout the whole year and was unaffected by issues beyond the expert team's control.

Data on swimming depth and temperature parameters were collected using monitoring systems developed by INCDPM (DKMR, DKTB-01T) [5,6], and installed at strategic points along the lower Danube River to ensure the connectivity of the areas of interest and to reflect the migration route of anadromous sturgeons from downstream (Black Sea coastline) to upstream (Bazias).

On the basis of the temperature and depth values detected by the stations for the tagged sturgeons to date, descriptive statistics (standard deviation, coefficient of variation) for each species were calculated using the corresponding formulas:

$$\sigma = \sqrt{\frac{\sum(x_i-\mu)^2}{N}} \quad (1)$$

Where: σ=standard deviation; x_i= each temperature/depth value detected; μ=mean of the values; N=total number of values (detections)

$$cv = \frac{\sigma}{\mu} \quad (2)$$

Where: cv=coefficient of variation; σ=standard deviation; μ=mean of the values.

This data will be employed in developing theoretical models based on the identification of minimum, mean, and maximum values of specific swimming parameters during the breeding season.

To validate hotspot areas for potential spawning habitats in the Lower Danube, values for additional stationary parameters (water velocity, substrate structure, and vegetation classes present in the spawning areas), as well as individual parameters (biometric parameters, movement speeds of tagged specimens, date and time of detection) will be recorded and analysed in the future for developing the theoretical models.

3 Results and discussions

Fig. 2 presents the distribution of wild sturgeon captures by year, representing the total number of the three species of interest: *Acipenser stellatus*, *Acipenser gueldenstaedtii*, and *Huso huso*.

Fig. 3 shows that the russian sturgeon was the rarest of the three anadromous sturgeon species in the lower Danube, as demonstrated by the percentage of each species in the catch relative to the same time, 2011-2022. As this species is the one most at risk of extinction, additional complex studies are required to determine the long-term viability of *Acipenser gueldenstaedtii* stocks in the Lower Danube, taking into consideration anthropogenic and climate change impacts.

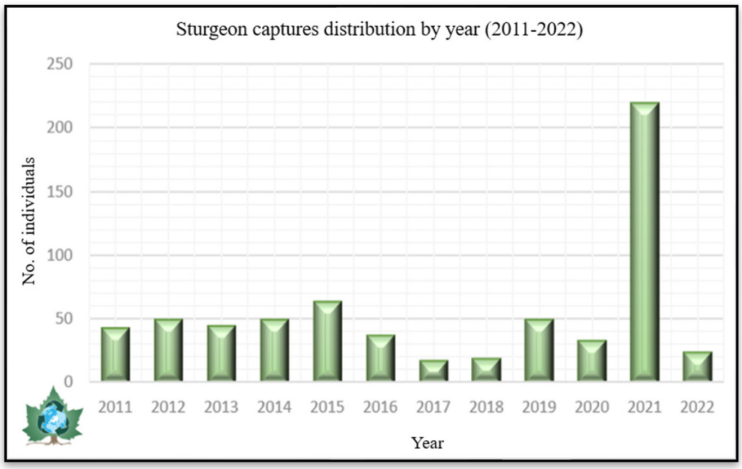

Fig. 2. Status of catches in scientific fishing activities from 2011 to 2022, relative to the number of individuals of all three anadromous sturgeon species analysed.

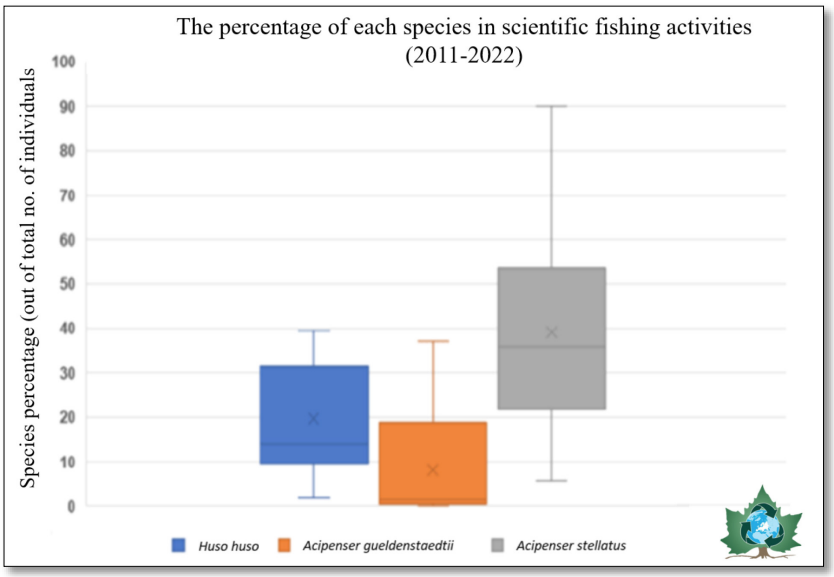

Fig. 3. Percentage status of anadromous sturgeon catches in scientific fishing activities from 2011 to 2022, relative to the number of individuals of each of the three species analysed (*Huso huso* – beluga sturgeon, *Acipenser gueldenstaedtii* – Russian sturgeon, *Acipenser stellatus* – stellate sturgeon).

In Table 1, it can be seen that, during the spawning period, the migration behaviour of anadromous sturgeon indicates a preference for areas with shallow depths of minimum 1.9m, maximum 20.3m and an average of 9.5m (beluga sturgeon), minimum 1.3m, maximum 22.1m and an average of 9.99m (russian sturgeon) and minimum 1.5m, maximum 27.6m and an average of 7.34m (stellate sturgeon).

The beluga sturgeon prefers conditions between 10.4 and 24.8°C (average 14.07°C), the russian sturgeon between 10.1 and 14°C (average 12.13°C), and the stellate sturgeon between 10.6 and 15.6°C (average 11.84°C). The highest temperatures were recorded in May (less frequently) and July predominately.

Table 1. Descriptive statistics characteristic of each species analysed, for the temperature and swimming depth parameters.

Species	Descriptive statistics	Depth (m)	Temperature (°C)
Beluga sturgeon Huso huso	min	1.90	10.40
	avr	9.50	14.07
	max	20.30	24.80
	SD	6.11	4.37
	CV	0.64	0.31
Russian sturgeon Acipenser gueldenstaedtii	min	1.30	10.10
	avr	9.99	12.13
	max	22.10	14.00
	SD	6.31	1.56
	CV	0.63	0.12
Stellate sturgeon Acipenser stellatus	min	1.50	10.60
	avr	7.34	11.84
	max	27.60	15.60
	SD	5.49	1.74
	CV	0.74	0.14

The analysis of the available data also reveals that beluga sturgeon has the highest depth preference (Fig. 4) while stellate sturgeon have the lowest, and that russian sturgeon have the highest thermal selectivity (Fig. 5), while beluga sturgeon appear to be the species least affected by water temperature values.

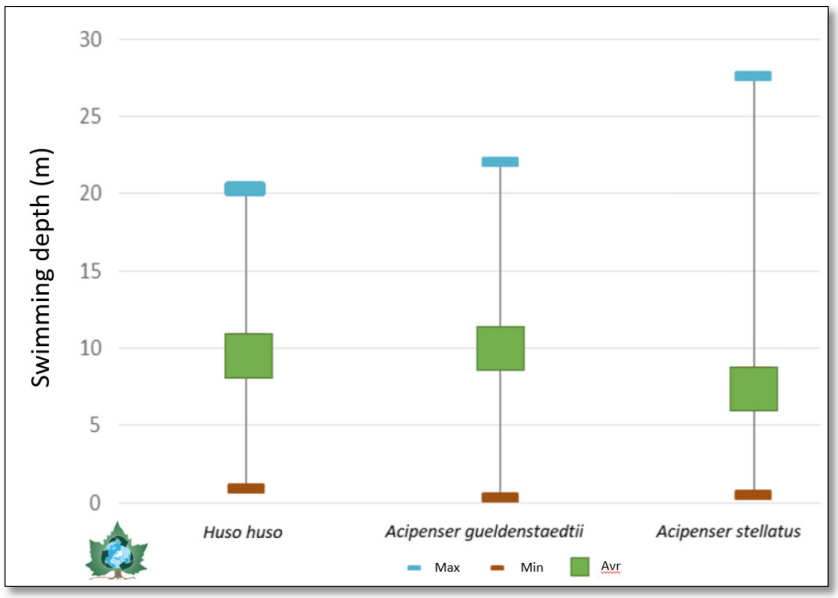

Fig. 4. Distribution of detected depth parameter values, by species (*Huso huso* – beluga sturgeon, *Acipenser gueldenstaedtii* – Russian sturgeon, *Acipenser stellatus* – stellate sturgeon).

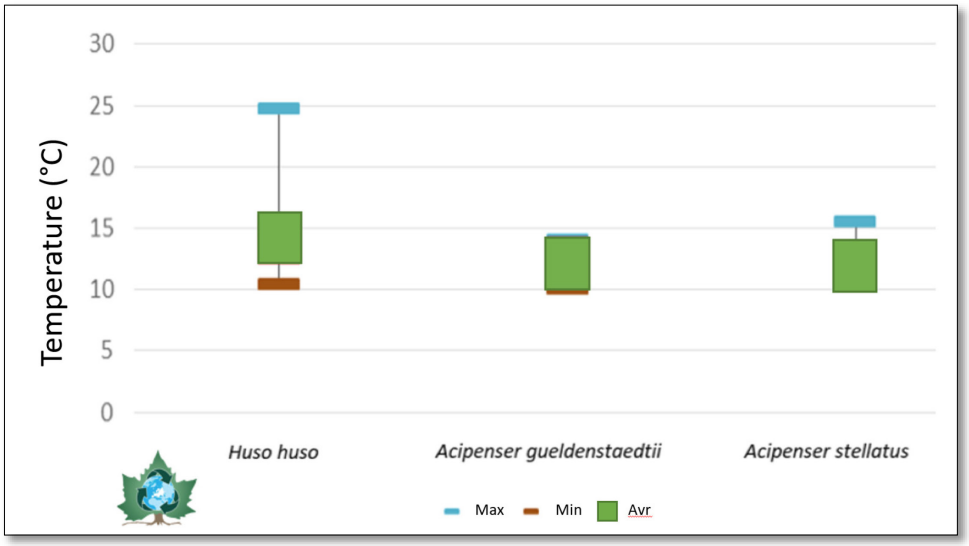

Fig. 5. Distribution of detected temperature parameter values, by species (*Huso huso* – beluga sturgeon, *Acipenser gueldenstaedtii* – Russian sturgeon, *Acipenser stellatus* – stellate sturgeon).

4 Conclusions

Sturgeon species have experienced massive stock losses as a result of the pressures they suffer from, which include overfishing and poaching, hydrotechnical constructions and changes to the aquatic environment, climate change, and pollution.

These anthropogenic and natural activities have contributed to the degradation of the aquatic environment and have a significant impact on biodiversity, frequently resulting in irreversible alterations.

The results indicate that, of the three species examined, beluga sturgeon has the highest selectivity for depth parameters, while the stellate sturgeon has the lowest. In terms of thermal parameters, russian sturgeon has the highest selectivity, with the majority of detections occurring within a narrow range of values, whereas beluga sturgeon is the species least affected by water temperature, with detections occurring within a wider range of values than the other two species analysed.

We can conclude that *Acipenser gueldenstaedtii* is the taxa most vulnerable to extinction, particularly in the context of climate change, given that the russian sturgeon is the species with the lowest percent from the total catches of the scientific fishing campaigns, in all the years in which they were conducted by the INCDPM's team of experts, but also the species with the highest preference for water temperatures during the migration period for reproduction.

Acknowledgement

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Sturgeon Population Monitored On The Danube, In Compliance With The Eu Mission And Biodiversity Strategy 2030 – Sturhabcons

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