“Dunărea de Jos” University of Galați

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PhD THESIS

ABSTRACT

RESEARCH ABOUT MIGRATORY BEHAVIOR OF MIGRATORY MARINE STURGEONS IN THE LOWER DANUBE RIVER USING TELEMETRY TECHNIQUES

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INTRODUCTION

The sturgeons belong to the *Acipenseridae* family, which comprises 27 species characterized by a cartilaginous skeleton, five longitudinal rows of bony plates, and no scales. The head has an elongated rostrum, with whiskers between the mouth and tip of the rostrum, and a ventral mouth. They are prehistoric fish that have survived for millions of years, belonging to the Triassic geological period (first period of the Mesozoic era dated between 250 – 200 mil. years ago) (Roland, 2000). Although sturgeons have survived for millions of years, their existence has become endangered, and nowadays many sturgeon species are threatened by extinction (Hensel, 1997). This happens due to overfishing, habitat modification (spawning and feeding habitats), river damming and pollution. The sturgeon breeding cycle covers a longer period of time compared with other fish species, reaching sexual maturity at the ages of 5 - 13 years. There are species that becomes adults at 26 years of age (Houston, 1987), a situation encountered in the female lake sturgeon (*Acipenser fulvescens*). Compared to other rivers flowing into the Black Sea, the Danube River is the richest in sturgeon (Hensel 1997) still having 3 wild anadromous species: Beluga Sturgeon (*Huso huso,)* Stellate Sturgeon *(A. stellatusI)* and Russian Sturgeon*, (A. gueldenstaedtii*), and one resided species, the Sterlet (*A. ruthenus*). Sturgeon fishing was a common occupation for the inhabitants who lived along Danube River banks since prehistory times, many sturgeon remains were found at settlements in the Iron Gates area (Bartosiewicz 2004). Sturgeons were caught during their migration using methods as stretched hooks lines, trammel nets and even by harpoons when they swam in the upper layers of the water (Seeley 1886).

Sturgeon fishing in the Danube River continued to fascinate travelers hundreds of years ago who described the capture of sturgeon in the Iron Gates area (Marsigli 1726), revealing the value of these species for the local fisherman's of that times. More data about sturgeon's fishing in Lower Danube River (rkm 0 Sulina – rkm 1075 Bazias) was collected at the beginning of the century XX when Antipa G. studied sturgeon fisheries located on the Saint George Danube branch (Antipa 1909). At that time Antipa described 6 sturgeon species, four of them are still captured in the Lower Danube River (LDR): Sterlet (*A. ruthenus*), Russian Sturgeon (*A. gueldenstaedtii*), Stellate Sturgeon (*A. stellatus*) and Beluga Sturgeon (Huso huso) (Antipa, 1909). Two sturgeon species are no longer reported to be captured in LDR the Ship Sturgeon (*A. nudiventris*) and Common sturgeon (*A. sturio*) (Otel 2007). The species which are still captured in the Danube River is Sterlet which is a freshwater fish living only in the river, an 3 anadromous species, which spend most of their life cycle in the Black Sea and migrate into rivers for spawning. Beluga Sturgeon (*Huso huso*) had two migration periods one in fall from late August to November and one in spring which could start in January depending on the water temperature and ended in May. Spawning takes place during the spring migration, sturgeon females laying eggs at depths of 8 – 20 meters at water temperature of 8 - 16 °C on clay, gravel or sand substrate (Dinu 2010). Similar with Beluga Sturgeons Stellate Sturgeon (*A. stellatus*) had two periods of migration one in fall which starts August and keeps until October (Bănărescu 1964) and the second one in spring during March – April when it has the spawning season at the water temperature of 8 - 11°C on clay or sand substrate (Otel 2007). Before the Danube River to be dammed, the sturgeons were able to migrate upstream as far as Komarno (Danube River km1, 810) to spawn (Bloesch, Jones 2006). The Beluga Sturgeon and Stellate Sturgeon use spawn further upstream in all rivers, therefore constructions of hydroelectricity or regulatory dams had a significant impact over natural reproduction of these species (Holcik 1989). Also the lack of viable solutions that ensure longitudinal connectivity for migratory species led to a dramatic decline in their number over the years (Hensel 1997).

In the past, the environmental impact on fauna got little attention but with the time it proved that modifying the natural course of the rivers cause significant changes over natural habitats and migratory routes of fish species, appearing new environmental concerns which increase requests for re-establishing longitudinal connectivity in the rivers. Regulation works on Danube River channels were documented since the 14thcentury in Austria, and a bigger regulation plan on Danube basin was accomplished between 1870 and 1875 (Winiwarter 2012). The discussion between Serbia and Romania for damming gorges area of Danube River, started after 1945 and had as the result construction of Iron Gate I dam at river km 943 which was put into operation in 1972 (Aaron 1996), followed by the construction of Iron Gate II dam at river km 864 which was put into operation in 1984 (Corda 1988). The presence of Beluga Sturgeons in the upper parts of Danube River was relatively common before the damming Iron Gate gorges (Bartosiewicz 2004). After Iron Gate II dam construction, a study was performed between year 1985 - 1986 to evaluate the construction impact over surgeon migration in the 864 river kilometre (rkm) stretch between the Iron Gate II Dam and Black Sea (Bratislava 1987). The 1990`s political changes in eastern part of Europe open the access to new modern techniques in tracking fish and has as the result a telemetry study over sturgeon migration in Lower Danube River which was conducted in 1998 when anadromous sturgeon species were tagged and tracked in Lower Danube River (Kynard 2002). More studies were conducted after 2009 in relation with sustainable tourism (Oddmund 2011), impact of navigation construction projects (Deak 2014) , or in relations with fish passage studies (Bruijne 2014; Bloesch 2016), when adult sturgeon were tracked in Black Sea and LDR using acoustic and satellite tags. Although in the past different telemetry studies were performed these were focused on small stretches of the Danube River or did not succeed to collect enough data to do a well documented analysis of sturgeon migration in the river. This work is the first one which is

able to do a more detailed analysis of adult sturgeon migration for Beluga and Stelate sturgeon in Danube River between rkm 71 and Iron Gate II dam using acoustic telemetry equipments. For this aliases were used telemetry data collected for a period of 6 years (2011 -2017). For the first time in Romania it was possible to do an analysis of the swimming depths recorded from the sturgeons during their migration in the river and a comparative analysis of their ground speed in different stretches of the river between rkm 71 and rkm 864. There was obtained data about sturgeons which were returned in the river 2 - 5 year after tagging proving in this way that the sturgeons from Danube River are not returning for spawning every year. These data have been corroborated with previously obtained data when sturgeons were recorded spawning in different breeding sites in the Lower Danube River.

The present thesis is made up of 8 chapters in which the migration behavior of migratory marine sturgeons is analyzed. The first chapter presents the ecology and status of sturgeons in the Black Sea and the Lower Danube River, and also briefly presents the state of sturgeon populations in Europe, Asia and North America. In the second chapter is analyzing the history of research in the field of sturgeon's telemetry and is making also a description of the equipment and methods used to track the sturgeon in the Lower Danube River. The chapter 3 described the materials and methods used in this study, and the locations where the sturgeon tracking equipment was installed as well as the tagged sturgeons from which the data of this study was obtained. The chapters 4 and 5 present the results of the research on migratory behavior in the Lower Danube River of Beluga, Stellate and Russian sturgeons. In this two chapters is analyzed the swimming ground speed, swimming depths for Beluga and Stellate Sturgeons and particular cases migration of specimens from these three anadromous species. In the chapter 6 there is an analysis of spawning behavior for the Beluga and Stellate sturgeons, describing the methods used to identify spawning periods that can be used to estimate the time when larvae and young of the year can be captured. The study ends with chapters 7 and 8 presenting the recommendations regarding the conservation of sturgeon species in the Lower Danube River and conclusions. All the analysis of collected telemetry data will help to improve knowledge of migratory behavior of marine sturgeons in the lower Danube. The results obtained can be used to improve the sturgeon life conditions as well as to restore the Danube's longitudinal connectivity by building fish passages that will help overcome the obstacles represented by the dams built on the river.

Research objectives

Although there have been previous telemetry studies, it have either focused on different sectors of the Danube River or have failed to collect enough data to carry out a more detailed analysis of sturgeon migration in the Danube. This research is the first study which did a more detailed analysis of the migration of adult Beluga Sturgeon, Stellate Sturgeon and Russian Sturgeon species in the Danube River sector located between the Iron Gate II dam and river kilometre (rkm) 71 using acoustic telemetry equipment. For this analysis data was collected during 6 years period (2011 – 2017) using electronic telemetry equipment. Thus, for the first time in Romania, using collected data obtained during the 6 years period, it was possible to analyze the swimming depths of sturgeon during their migration in the Danube River, and also it was possible to do an comparative analysis of the adult sturgeons ground speeds in different sectors of the river between rkm 71 and rkm 864. Data about sturgeon returns to the Danube River has been obtained and analyzed, which confirm that the sturgeons do not return annually to the Danube River to reproduce, they return every 2 - 5 years depending on species and sex. These data have been compared with previously data about periods when sturgeons spawn in different spawning sites located in the Lower Danube River. The present study is made up of 8 chapters in which the migration behavior of migratory marine sturgeons is analyzed. The analysis of collected telemetry data will help to improve knowledge about migratory behavior of adult marine sturgeons in the Lower Danube River. The results obtained can be used to improve sturgeon’s habitats and to restore the Danube's longitudinal connectivity by constructing fish passages that will help migratory fishes to overcome the obstacles like hydroelectric dams built on the river.

Description of the telemetry equipment used

The choice of tags in a migratory fish telemetry study depend on the target species, respectively, on the size and sensitivity of the studied species, but also on the conditions of the living environment in which they are studied. In this case the target species were represented by the adults of Beluga Sturgeons, Stellate Sturgeons and Russian Sturgeons which are leaving the Black Sea when they became adults and migrate in the Danube River to spawn. Adults of these three species at the time they reach maturity have large a size in case of Stellate Sturgeons over one meter, over 2 meters for Beluga Sturgeons and smaller sizes for Russian Sturgeons. Large fish sizes of these sturgeons’ species make it possible to use larger tags that can be equipped with multiple sensors or multiple batteries to extend their lifetime.

Acoustic tags used:

- **V13TP-1x**
- **V16TP-6x**
- **Thelma 16 mm tag**

The V13TP-1x acoustic tag has a smaller diameter than the V16TP acoustic tag, and can be used to tag smaller fish. The tag can be equipped to transmit only continuous signals or may be equipped with depth and temperature sensors. The V13 acoustic tags used to track sturgeons are equipped with temperature and depth sensors capable of transmitting temperatures ranging from 0-40 ° C (accuracy of ± 0.5 ° C and resolution of 0.15 ° C) and depths of up to 50 m (accuracy ± 2.5 m and a resolution of 0.22 m at room temperature). The V13 acoustic tag used for tracking sturgeons in Lower Danube River transmits the signal over a wavelength of 69 kHz and has an estimated duration of operation of 450 days, being programmed to emit a low intensity signal over a time interval between randomly selected signals but within the time interval 30 - 90 seconds (Figure 1.a). Each V13TP is provided with a serial number (SN) and an identification number (ID) for each tag sensor. (For example, if the tag has two sensors, one ID is for temperature and one ID is for deepth, so there will be two IDs, one for each sensor).

Figure 1 (a) Vemco tag V13TP; (b) Thelma tag 16 mm, (c) Vemco tag V16TP and sensor

The Thelma 16 mm tag transmits the signal using a wavelength of 69 kHz.

The 16 mm Thelma acoustic tag ADT-MP-16 type (Acoustic Depth Transmitters - Medium Power - 16 mm) is a large tag with an estimated battery life of 3600 day emits at signals at an average of 40 seconds, at medium intensity / power. These acoustic tags have worked well used in combination with the Vemco VR2W receivers. The 16 mm Thelma tags can be used both for active tracking of tagged fish and for passive tracking. The V16TP-6x acoustic tag (Figure 1.c) is a large tag that has an estimated battery life of 2613 days being scheduled to emit in two steps. The first step will emit signals for 300 days randomly in the interval of 15 to 45 seconds at high power / high, (2nd step) the remaining 2323 days will emit signal with low power randomly in the time interval of 30 - 90 seconds. The tags emits signal using 69kHz wavelengths and can transmit temperature data up to 40 ° C (accuracy ± 0.5 ° C and resolution of 0.15 ° C) and depths up to 34 meters (accuracy ± 1.7 m and resolution 0.15 m at room temperature). Each tag is provided with a serial number (SN) and an identification number (ID) for each tag sensor.

Acoustic receivers used in the study:

- **VR 100 acoustic receiver**
- **VR2W acoustic receiver**

The VR 100 Acoustic Receiver (Figure 2.a) is a specially designed for mobile / active tracking of tagged fish using a boat (Figure 2.b).The receiver can be used for both continuous signal detection of acoustic tag but also for detection of the tags equipped with sensors (Figure 1). The VR 100 acoustic receiver can be connected to a multi-directional hydrophone or to a one-way hydrophone for a more accurately identification of the tagged fish location.

Figure 2 (a) VR100 acoustic receiver, (b) Sturgeon manual / active tracking in Danube River using VR100 acoustic receiver, (c) VR2W acoustic receiver

The VR2W acoustic receiver (Figure 2.c) had the electronic part, battery and the hydrophone incorporated in a very solid cylindrical plastic case that may resists to high pressures and shocks and can be installed in water at depths of up to 500 meters. The receiver is equipped with a Bluetooth to communicate with a PC using the VUE software to download the recorded data. The VR2W receiver hand a Smart LED that helps to identify the receiver's operating status. Data storage is done on 8 MB internal FLASH memory that allows one million detections to be recorded. Each VR2W receiver has a 4-digit series that is printed on its housing. To download the data, a magnetic key is used to activate the receiver to connect to the PC via the VUE software.

Research about Beluga Sturgeon migration behavior in the Danube River

For a better understanding of the sturgeon migration behavior, a total of 81 specimens of sturgeons have been tagged with acoustic tags and tracked over the period of 6 years. From these sturgeon specimens 36 were Beluga Sturgeon (*Huso Huso*), 44 specimens were Stellate Sturgeons (*Acipenser stellatus*) and just one specimen was Russian Sturgeon (*Acipenser gueldenstaedtii*). Total length of the tagged Beluga Sturgeon was between 185 cm and 255 cm and Stellate Sturgeon between 75 cm and 135 cm (Figure 3)

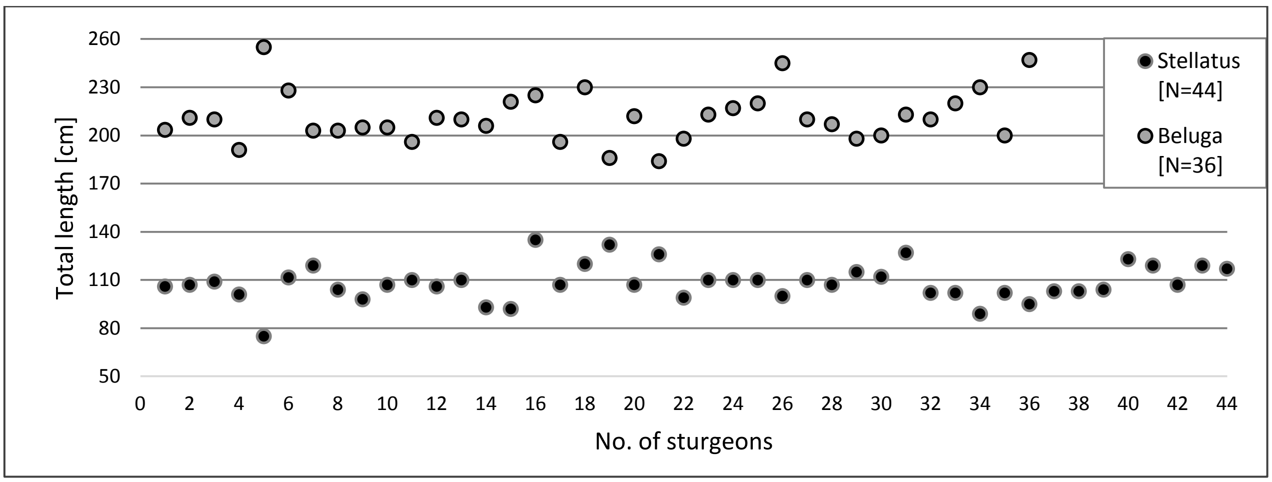

Figure 3 Total length distributions for Beluga and Stellate Sturgeon

From all 81 tagged sturgeons with acoustic tags (Beluga, Stellate and Russian Sturgeons) 19 sturgeons (24% of the total) were never recorded after their tagging and release in the Danube River. Most of the tagged sturgeons 42 % were recorded within the first 10 days of their release in the river. Just 6 % form all 81 tagged Beluga, Stellate and Russian Sturgeons returned in the river after a period of time longer than 365 days from their tagging and releasing. A number of 16 sturgeons (20% of total) were recorded after a period of time longer than 30 days. A smaller number of sturgeons were recorded between 10 and 20 days (5%) and between 20 and 30 days (3 %) since their releasing in Danube River (Figure 4). Many recorded detections from these tagged adult sturgeon specimens were used to study their migration routes during spawning migration but also for the comparative analysis of swimming depths and migration ground speeds during upstream and downstream migration. Unfortunately, there was no possibility of detailed analysis of the Russian Sturgeon (*Acipenser gueldenstaedtii*) because was not enough specimens captured of this sturgeon species. The only one specimen of Russian Sturgeon captured and tagged was in 2011, which provided little data on the migration of this anadromous migratory sturgeon species.

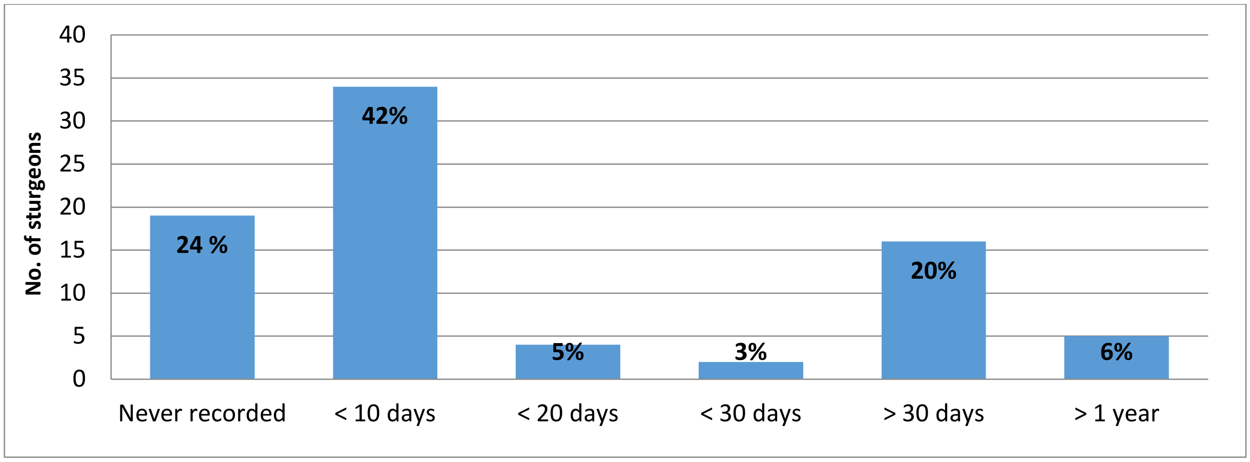

Figure 4 Beluga and Stellate Sturgeons recorded at different time intervals [N=80]

From October 2011 until the beginning of 2017, 36 Beluga Sturgeons (Huso Huso) were tagged and tracked during a 6 years' time period, the many of them being captured and tagged at river km 300. From all 36 tagged Beluga Sturgeon with acoustic tags, 6 of them (17%) were never recorded after their tagging and release in the Danube River. Most of the tagged Beluga Sturgeons 42% (15 specimens) were recorded in the first 10 days after their release. Two Beluga Sturgeons (5%) of all 36 tagged specimens returned in the Danube River after a period of time longer than 365 days since the releasing. One of these two Beluga Sturgeons returned in 2016 after a period of 5 years from the tagging, and a second one returned to the Danube River two years after tagging respectively in autumn of 2014 but it spawn during the spring of the next year. A number of 11 tagged Beluga Sturgeons (11%) were recorded after a period longer than 30 days since their releasing in Danube River.

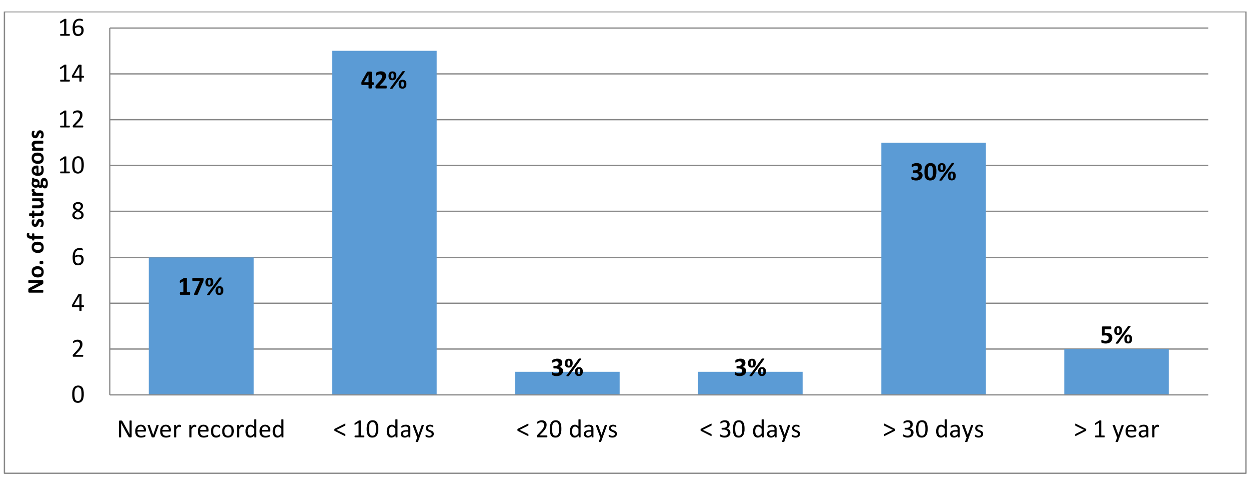

Figure 5 Beluga Sturgeons recorded at different time intervals [N=36]

These Beluga Sturgeons provided most of the data which was used for the swimming speed and swimming depth analysis during their spawning migration in Lower Danube River. A smaller number of tagged Beluga Sturgeons were recorded in a 10 – 20 days (3%) and 20 – 30 days (3%) period of time, since their releasing in the river (Figure 5).

Research on migratory behavior of Beluga Sturgeons in the Lower Danube River

Beluga Sturgeon swimming depths analysis

To identify preferred swimming depths during their spawning migration a total of 8111 swimming depths detections transmitted by the Vemco V16TP tags have been analyzed for Beluga Sturgeon. These data were collected from 23 tagged Beluga Sturgeons during Nov. and Dec. 2011; Jan., March., Apr., May, June and Nov., 2012; Apr. and Nov. 2014; Apr. 2015. The collected swimming depths data from Beluga sturgeons which were recorded by the VR2W receivers installed in the Danube River between rkm 71 (Tulcea branch) and rkm 847 reveal that the swimming depth range was between 1 and 36 meters (Figure 6). Many swimming depths detections (77%) for downstream (d/s) and upstream (u/s) migration were in the range of 8 to 22 meters deep with the most detections recorded in the interval of 10 to 11 meters (11%). For downstream migration most of the depth detections were in the 2 to 19 meter interval, with the highest frequency at a depth of 8 to 9 meters (13%). Half of these depth detections were in the interval of 8 to12 meters (Figure 6). In the case of upstream migration 82% of detections were in the interval of 8 to 21 meters deep, with the highest fervency at a depth of 10 - 11 meters (11%). More than half of these depth detections were in the interval of 9-15 meters (Figure 6).

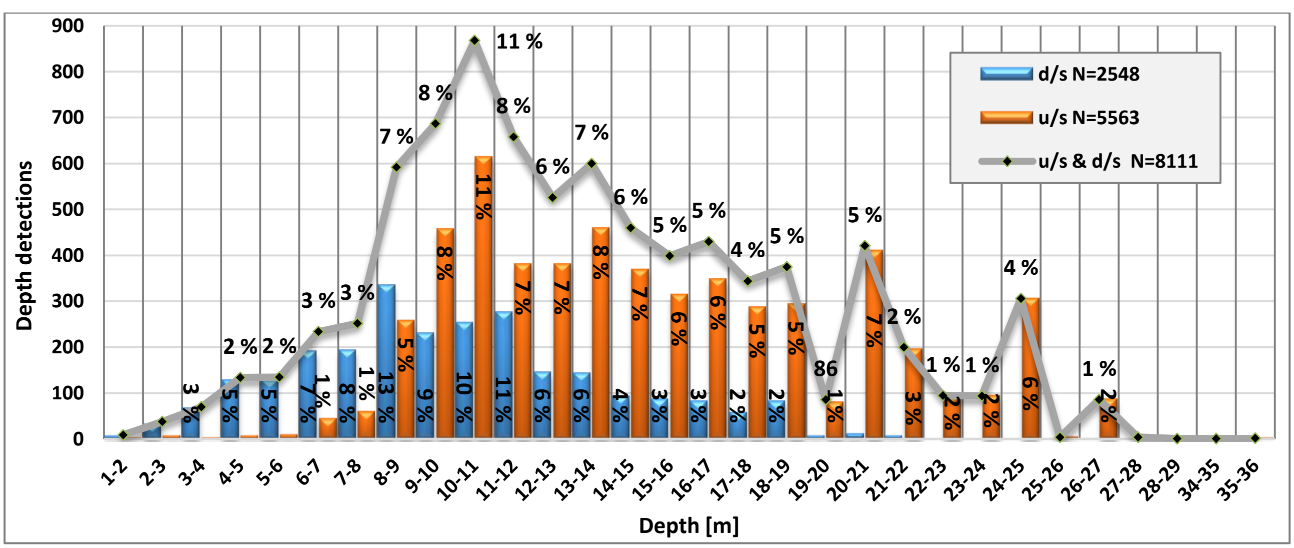

Figure 6 Beluga Sturgeon depth detections recorded in Danube River between rkm 71 and rkm 847

Beluga Sturgeon swimming speed analysis during migration in the Lower Danube River

The Beluga Sturgeon ground speed for upstream movement was in the range of 1.1 – 2 km/h higher than the Stellate Sturgeon upstream ground speed (0.34 – 0.36 km/h). The Beluga Sturgeon ground speed during the downstream migration increased by up to 6 km/h for Beluga (Table 1). Comparing ground speeds recorded shortly after tagging with the ground speeds recorded 90 days later for Beluga Sturgeon; there was a difference for minimum downstream values recorded and no difference for maximum values (Table 1).

Table 1 Upstream and downstream estimated ground speed for Beluga Sturgeon

Nr. Crt.	Criteria	Species	Upstream (u/s) [km/h]		Downstream (d/s) [km/h]	
			Min.	Max.	Min.	Max.
1	all data	Beluga	**1.1**	**2**	**0.49**	**6**
2	Soon after tagging	Beluga	**-**	**-**	**0.49**	**6**
3	90 days after tagging	Beluga	**1.1**	**2**	**1.16**	**6**

Research on migratory behavior of Stellate Sturgeons in the Lower Danube River

The anadromous sturgeon from Black sea has two migration periods, one in fall and one in the spring. Sturgeons entering the Danube River in fall overwinter in the river and continue their migration the following spring when they spawn (Antipa 1909, Shubina et al. 1989). Different migration behaviors can indicate different population segments (Waples et al., 2001) that require special / separate conservation measures in distinct management units. The study of migratory behavior using telemetry equipment makes a significant contribution to understanding the behavior of sturgeons in the population. A better understanding of studied sturgeon species from Danube River helps significantly to identify the necessary measures to support these endangered populations. Between June 2011 and November 2015, 44 specimens of adult Stellate Sturgeons with a total length in the range of 75 cm and 135 cm (Figure 3) were captured and tagged with acoustic tags. The data obtained from these 44 adult Stellate Sturgeon were used to study their migration routes during spawning migration, but also for comparative analysis was done for swimming depths and migration ground speeds during upstream migration compared to migration downstream migration. From all the 44 Stellate Sturgeon tagged with acoustic tags, 30% of the total (13 specimens) were never recorded after their tagging and release in the Danube River (Figure 7).

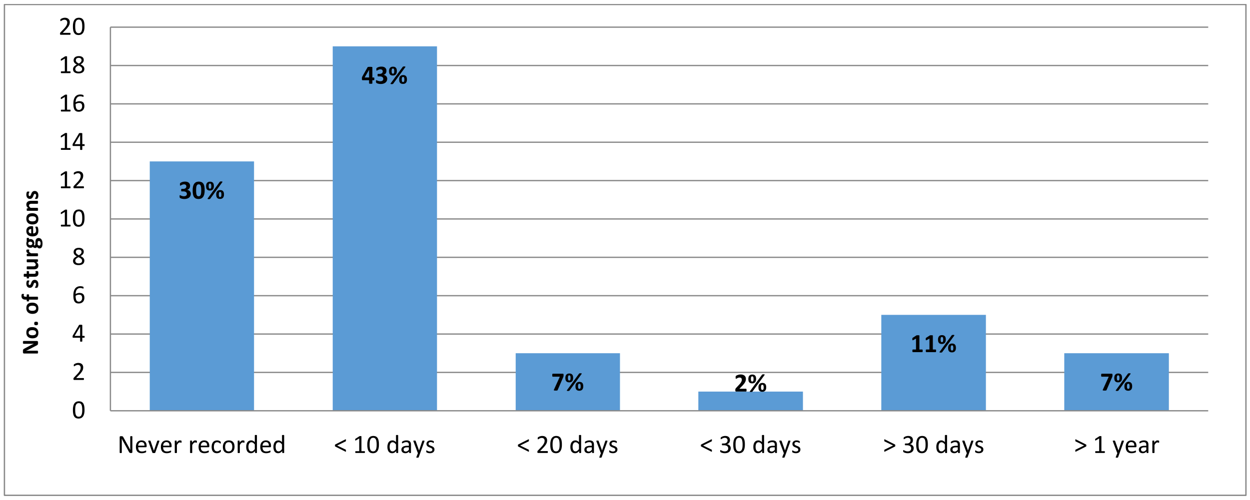

Figure 7 Number of Stellate Sturgeons recorded at different time intervals [N=44]

Most of the tagged Stellate Sturgeon 43% (19 specimens), were recorded within the first 10 days of their release. These Stellate Sturgeons, along with specimens that were recorded less than 20 and 30 days after tagging and releasing along with the specimens that were recorded more than 30 days after release, provided the most data used for the ground speed and swimming depth analysis of the Stellate Sturgeon spawning migration in Danube River. Three Stellate Sturgeons (7%) were recorded within the first 20 days of release and only one Stellate Sturgeon (2%) was recorded within the first 30 days of release into the river. Five Stellate Sturgeons (30%) were recorded more than 30 days after their release to the Danube River, and a number of 3 tagged specimens (7%) returned to the Danube more than 365 days after their release (Figure 7). One Stellate Sturgeon returned after a period of 4 years after tagging and release in Danube River and two other specimens returned two years after tagging.

Stellate Sturgeon swimming speed and swimming depth analysis during migration in the Lower Danube River

Stellate Sturgeon swimming depths analysis

To analyze the swimming depths for Stellate Sturgeons, a total of 472 recorded depth detection were used from 21 tagged specimen with acoustic tags equipped with depth and temperature sensors. The data used for swimming depth analysis were downloaded from 7 VR2W acoustic receivers installed in the Lower Danube River between km 71 and km 200. Most of the swimming depths obtained from the 21 specimens of Stellate Sturgeon were within the depth range of 2 to 17 meters. A number of 63 swimming depth detection (13%) from the total of 472 analyzes detections were in the depth range of 5 to 6 meters (Figure 8.).

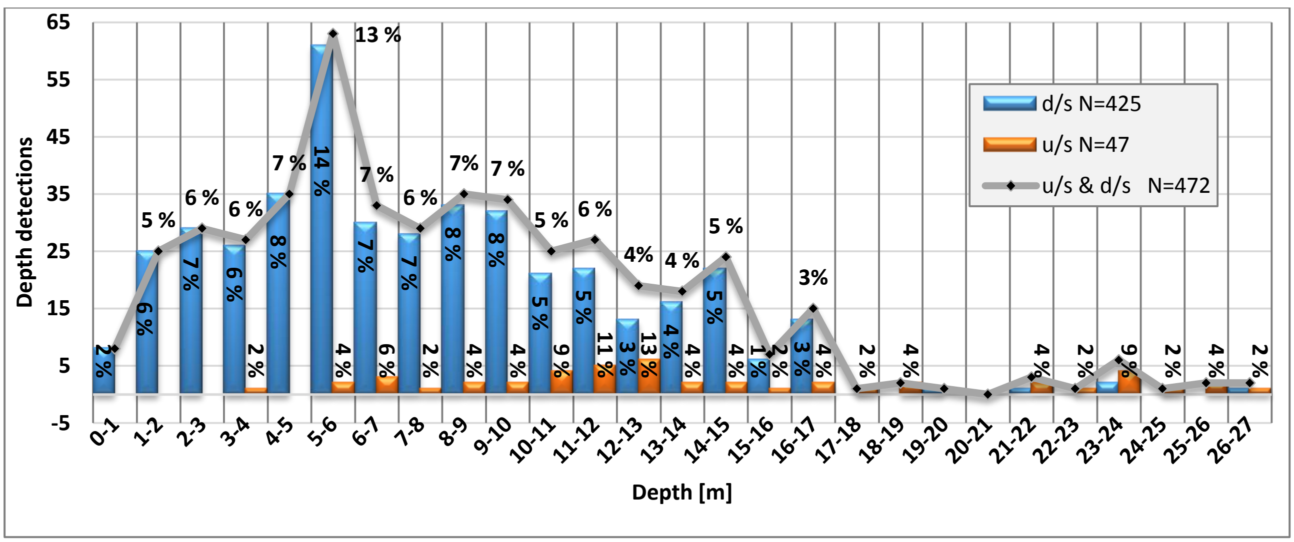

Figure 8 Stellate Sturgeon depth detections recorded in the Lower Danube River between rkm 71 and rkm 200

Many of the depth detections recorded during downstream migration was in the depth range of 1 to 17 meters. Most of them (14%) were in the depth range of 5 to 6 meters. In case of the upstream migration of the Stellate Sturgeons, most of the recorded depth detections were in the range of 5 to 19 meters (73%). The recorded depths with the highest frequency are in the range of 12 and 13 meters (13%). A 23% percentage of the depths recorded during the upstream migration were in the depth range of 22 to 27 meters (Figure 8).

Stellate Sturgeon swimming speed analysis during migration in the Lower Danube River

The ground speeds were estimated as a result of the data analysis obtained from Stellate Sturgeons tagged with acoustic tags during their migration between Danube River km 71 and km 200. The maximum and minimum ground speed estimated during spawning migration for Stellate Sturgeon was in the range of 0.34 to 4.83 km / h (Table 2). The estimated ground speed for Stellate Sturgeon is smaller compared to the ground speed estimated for Beluga Sturgeon, for instance the maximum ground speed for Stellate Sturgeon was 4.83 km / h and for Beluga Sturgeon 6 km / h.

Table 2 The estimated ground speed for Stellate Sturgeon during the migration in Lower Danube River

Nr. Crt.	**Criteria**	**Species**	**Upstream (u/s) [km/h]**		**Downstream (d/s) [km/h]**	
			Min.	**Max.**		**Min.**
1	all data	Stellate	**0.34**	**0.36**	**0.4**	**4.83**
2	Soon after tagging	Stellate	**0.34**	**0.36**	**0.4**	**4.83**
3	90 days after tagging	Stellate	**-**	**-**	**-**	**-**

It was not possible to compare the estimated ground speed for Stllate Surgeon soon after tagging with the estimate ground speed after 90-day since the adult Stellate Surgeons were tagged and released, because there was insufficient data to perform this analysis (Table 2).

Conclusions

The migratory fish are migrating due to food and breeding reasons, and in case of the Beluga and Stellate Sturgeon the best place to breed is not the same place for feed. So they need to migrate in the rivers further upstream to the spawning sites which meet the condition for laying the eggs. During migration, Beluga Sturgeon can travel long distances. For example, a Beluga which was tagged in November 2013 passed rkm 100 moving downstream came back upstream in March 2014 to rkm 100. It then migrated 747 km upstream to rkm 847 in 18 days, covering an average of 41.5 km/day (1.7 km/h), and then travelled downstream 747 km in the same number of days (18 days). A second Beluga Sturgeon tagged in 2011 returned to the Danube River in 2016 being recorded downstream of the Iron Gate II dam in April 2016, moved downstream 747 km in 13 days between rkm 847 and rkm 100, an average of 57.5 km/day (2.4 km/h). Beluga and Stelatte sturgeon first migration in Danube River begin in spring and second migration occurs during the fall. The spring migrations for Beluga Sturgeons occur from February to May and for Stellate Sturgeon begin in March and ends in May (Otel 2007). The fall migration for Beluga sturgeon begins in August and last in November - December depending of water temperature and for Stelate Sturgeon migration is from August to November (Banarascu 1964). The fall migratory sturgeon overwinters in the river and spawn next year and the sturgeons which are migrating during the spring spawn in the same year (Otel 2007, Suciu et al., 2016). It is generally accepted that the sturgeon which are entering the river during the fall migration want to get further upstream because they are able to continue their migration early in the spring. In Danube River and in Volga River are more Beluga Sturgeons migrants in the fall migration than in the spring migration (Holcik 1989). In this study most of the detection analyzed at rkm 100 are from the fall migratory Beluga Sturgeon. In case of Stellate Sturgeon most of the migratory specimens are captured during the spring migration (Holcik 1989).

The results for Beluga Sturgeon swimming depth detections show a preference for 8 - 12 meter depths for downstream migration and 9 -15 meter depth for upstream migration. The shallowest depths detections were between to 1 - 2 meters and the deepest detections recorded were between 35 - 36 meters. At the beginning of the 19th century the fishermen used to install hooks in the Danube River to catch sturgeons during migration. Depending on the season, they placed hooks during the spring at depths of 7.5 meters and in the fall to 30 meters deep (Antipa, 1916). For example the wintering depths of Stellate Sturgeons from the Northern Caspian Sea are 1.8 – 3.6 meters (Holcik, 1989). In case of the Stellate Sturgeon swimming depths recorded in Danube River, the range was between 1 – 27 meters deep, most of the detections for downstream migration were between 1 – 17 meters and for upstream swimming between 3 – 27 meters deep. The results reveal that the Beluga uses to swim in deeper waters than the Stellate Sturgeon. Stellate Sturgeon were previously recorded in the Danube River swimming upstream at 7– 8 km/day (0.33 km/h) and 20 km/day (0.83 km/h) during downstream migration (Kynard, 2002). The estimated migration speed relative to the riverbank (ground speed) for Stellate Sturgeon in the Volga River is from 18-20 km/day (0.83 km/h) (Khodorevskaya, 2009) to 110 km/day (4.6 km/h) (Holcik, 1989). In the Kura River the estimated ground speed is 20 km/day (0.83 km/h), and for the Kuban River 24 km/day (1 km/h) (Khodorevskaya, 2009).

Using acoustic telemetry equipment, it was possible to observe that adult specimens of Beluga and Stellate Sturgeons are still migrate to the Danube up to river km 860 - 864 (where the first dam is located), which makes us believe that these fish migrate here because they want to move upstream of the Iron Gate II Dam. There were fears that, in time, the sturgeons will no more try to pass the dam / return to the places where they were born (lose the homing instinct) due to their inability to cross the dams built on the Danube River more than 30 years ago. There are studies that have questioned and analyzed whether or not there is a homing instinct in migratory fish; to return to the place where they were born to spawn like their parents did (Barbaro 2008). There are authors that claim that fish migration is based on the olfactory sense (Bett 2016), but also authors who notice a strong instinct for the sturgeon to return and reproduce in the same location where they was born (Lagutov 2008; Nelson et al 2013). There is a great probability that the sturgeon upstream migration is not affected by one single factor but by several cumulative factors that influence the upstream migration. The presence of sturgeons downstream of the Iron Gate II Dam more than 30 years after the completion of the last dam in the Lower Danube River reveal the importance of this research. The collected data can be used for a better understanding of sturgeon migration and the factors that influence their migration. Because the Beluga and Stellate Sturgeons adults were recorded close to the dam, being attracted by the water currents from the turbines of the power plant, it demonstrates that the sturgeons still try to move upstream of the barrier represented by the construction of the hydropower plant. These data about sturgeon's presence downstream the hydropower plant and the places where they are crowded are very important for the construction of passages for fish migratory species which wants to migrate upstream the Iron Gate II Dam.

In this study it was observed and confirmed that the sturgeons which are wintering in the Danube River reduce their movement when the water temperature is below 6 ^{0}C. For example, the Caspian Sea, Beluga Sturgeon during the winter is migrating from the south and centre of the sea to the north of the Caspian Sea, and begin to swim to the deeper seaside areas when the water temperature drops to 6 - 4 ^{0}C reducing their movements (Khodorevskaya 2009). This behavior can also be observed in the Beluga Sturgeons which are migrating in Danube River, which around the 4 ^{0}C temperature, they significantly reduce their movements in the river. The Beluga Sturgeons are wintering in the Danube River in deep holes located on the bottom of the river to conserve their energy for spring migration. These holes are usually formed by the elbows of the river which appears in the locations where the water met rocky bank and is redirected in the opposite direction and dig deep into the bottom of the river (Antipa 1909). An example of wintering behavior in the Danube River is that of Beluga Sturgeon with no. file 11_20_03 which had been wintering in the holes formed in the area called "Cotul Pisicii" where the Danube forms large meanders due to the rocky area. This area was well known in the past for the large sturgeons catches (Antipa 1916), the area benefiting also from good fishing locations due to the fact that the width of the river is not very large, and due to the shape of the Danube river bed in the area that allows fishing with bottom nets. It can also be seen from the data collected from adult specimens of Beluga and Stellate Sturgeons that the vast majority of the recorded detections were during the night or in the morning, few detections being recorded during the day. Most of the tagged Beluga and Stellate Sturgeons reveal a similar behavior after tagging, shortly after the release these sturgeon specimens, had a continuous drop back movement that was probably the result of the stress caused by capture, tagging or transport. Therefore it is recommended that in the case of fish behavior studies; the fish should be kept in captivity as short as possible to avoid long - term manipulation and to reduce the stress caused due to the tagging of the fish (Koeck 2013). The reducing of the stress caused by manipulation and tagging is needed to avoid altering the migration behavior and to obtain results that are influenced as little as possible by external / anthropogenic factors.

Because there are wild sturgeon species that migrates in Danube River to spawn provides the opportunity to study their migration for a better understanding of the sturgeon spawning migration behavior. So in order to find new habitats used by sturgeons in Lower Danube River, a new method was developed to indentify the spawning date for Beluga Sturgeon; a method that has helped to identify the periods when the larvae can be captured, indentifying in this way the Beluga Sturgeon spawning habitats. The method developed by the Sturgeon Research Group (SRG) - team within the DDNI Tulcea, and contributed to identifying new spawning habitats of adult Beluga and Sterlet Sturgeons and has significantly reduced the workload required to capture larvae by accurately identifying the date when larvae start move into the river. For example the larvae of Beluga and Sterlet Sturgeons were captured in 1999, 2004, 2007, 2008, 2010, 2013, 2015 (Onără 2011, Suciu, 2013) confirming in this way the existence in the Lower Danube River of two spawning sites at rkm 310 (red stone) and 100 rkm. In case of Stellate Sturgeon spawning date, the analysis started with the young of the year this species captured at Danube River km 123, and reveal that the method which provided results for Beluga Sturgeon can be also applied to Stellate Sturgeon using the Ivanov table (1987) for this species and data about Danube water temperatures and evolution of water level in the river. In order to confirm that this method is working for Stellate Sturgeons, it should be tested in the field whether or not is good for identifying the exact date of spawning and movement of the larvae in order to catch them. The capture of the Stellate Sturgeon larvae can be accomplished with the bottom nets used for capturing Beluga Sturgeon larvae before, and in the same time, the Stellate Sturgeon larvae may be captured using nets installed in the water flow. By capturing the Stellate and Beluga Sturgeons larvae, it is possible to identify exactly the spawning areas of these sturgeon species. By certifying the methods of capturing larvae in both species it is possible to establish the method that can be used for the identification and mapping of the spawning habitats of the Stellate and Beluga Sturgeons in the Lower Danube River. The identification of spawning sites will allow more detailed analysis of these habitats and punctual implementation of measures to protect spawning areas, especially in the period of time when these sturgeon species are migrating in the river to spawn. By deepening the knowledge of sturgeons spawning behavior in Lower Danube River, identifying and analyzing the specific habitats used by these species, better action can be taken to improve the spawning conditions of these sturgeon species. These actions should improve the Beluga and Stelate Sturgeon spawning in their natural habitat and help to restore the sturgeon populations of the Danube River.

The present research is the first study that has proposed and managed to track the sturgeons in Lower Danube River between rkm 71 and rkm 864, a sector of the river which has a total length of 793 km. Due to the length of the river sector where the anadromous sturgeons were studied and the number of sturgeon tagged with acoustic tags, it was possible to collect new data that were not obtained in previous studies. These data were used to analyze the Beluga and Stellate sturgeon ground speed during their migration in the Lower Danube River by studying their movement in different sectors of the river where acoustic receivers were installed. The results of the Beluga and Stellate sturgeon ground speed were compared with literature data from the same sturgeon species. The data about Beluga and Stellate Sturgeon ground speed movement in the Lower Danube River were obtained by analyzing the ground speed obtained form 24 sturgeons (Beluga and Stellate Sturgeon) that have travelled in different sectors of the river over distances between 6 km and 747 km. Although this analysis is doing just an estimation of the sturgeon ground speeds movement, knowing that fish is not swimming in a straight line (Christopher 2007), the data obtained contributes significantly to the understanding of the sturgeon migration between the Iron Gates 2 and the Black Sea. Because the acoustic tags were able to record both the temperature and swimming depths during sturgeon migration, it was possible for the first time to analyze a consistent number of swimming detection obtained from tagged sturgeons that migrated in the Lower Danube River to spawn. As a result a total of 8111 swimming depths detections were obtained and analyzed from 23 Beluga Sturgeons, data that were downloaded from 10 VR2W submerged acoustic receivers installed in the Danube River between rkm 71 (Tulcea branch) and rkm 847. In the case of the Stellate Sturgeon a number of 472 swimming depths detection were obtained from 21 Stellate Sturgeon specimens, data which were downloaded from 7 VR2W submerged acoustic receivers installed in the Danube between rkm 74 and rkm 200. Analyzing the data obtained it could be seen that the Beluga Sturgeon are swimming in deeper water of the river compared to the Stelate Sturgeon and also it was observed that the Beluga Sturgeon is moving

faster than the Stelate Sturgeon specimens, for both upstream migration and downstream migration .

These results contribute to a better understanding of the Beluga and Stellate Sturgeon migration behavior in the river sectors they are using, in order to identify new spawning and feeding habitats in the 864 rkm which had no dams. The identification of new spawning and feeding sites will help in find the best solutions to protect them during the planned dredging works which will be done for maintaining conditions for navigation between rkm 375 and rkm 863 in the Danube River**.** It also contribute to the efforts for better understanding of sturgeon migration in order to establish longitudinal connectivity of the river by building fish passages at Iron Gate II dam. More research will be carried out in these directions to protect sturgeon species form the Lower Danube River.

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