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Contributions to understanding the fall migration of beluga sturgeon (*Huso huso)* on the Lower Danube River, Romania

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Abstract. Within this article the authors present the processing of an informational volume, unique on both national and international plan, referring to sturgeons' migration on Danube. In order to present the results of the monitoring activity, carried out by a researching mix team of the above mentioned institutes, we chose the marine sturgeon beluga (*Huso huso).* The objective is to offer exclusive results regarding the migration of this sturgeon species in order to elaborate some protection and conservation measures in the future, taking into consideration the fact that this species is mentioned starting April the 1st 1998 in the 2nd axis of The Convention of International Trade in Endangered Species of Wild Fauna and Flora. This paper is based on Lower Danube's monitoring section, covered between km 175-375, using specific techniques (DKTB station to monitor the ichtyofauna, especially sturgeons, through remote sensing, with ultrasonic tags in different hydromorphological conditions, file number: no. A100773/30.10.2012). The article presents the results that come to improve the existent informational volume throughout the identification of some migrating routes of the sturgeon (beluga species) directly correlated to water temperature, swimming depth and geodesic localization as well as indirectly with the average velocity of movement. The exceptional character of this paper consists in the fact that until now, in Romania, there has not been possible the accomplishment of sturgeons' migration monitoring on a significant number of individuals and on a distance of more than 400 km, using ultrasonic tags.
Key Words: Beluga, *Huso huso,* migration, monitoring, swimming velocity.

Rezumat. În acest articol autorii prezintă prelucrarea unui volum informaţional unicat pe plan naţional şi mondial referitor la migraţia sturionilor pe Fluviul Dunarea. Pentru exemplificarea rezultatelor monitorizării efectuate de o echipa mixtă de cercetători ai instituţiilor menţionate în titlu s-a ales specia de sturion marin denumită morun (*Huso huso*). Obiectivul constă în a oferii rezultate unicat referitor la migraţia acestei specii de sturion în vederea elaborării în viitor a unor măsuri de protecţie şi conservare având în vedere faptul că specia este prevazută in axa a II-a a The Convention of International Trade in Endangered Species of Wild Fauna and Flora începand cu 1 aprilie 1998. Prezenta lucrare se bazează pe monitorizarea sectorului Dunării Inferioare cuprins între km 175 şi km 375 utilizând tehnici specifice scopului urmărit (staţie *DKTB* de monitorizare a ihtiofaunei şi în special a sturionilor prin teledetecţie cu marcă ultrasonică în diferite condiţii hidromorfologice, dosar brevet nr. A100773/30.10.2012). Articolul prezintă rezultate ce vin să îmbunătăţească volumul informaţional existent prin identificarea unor rute de migraţie a sturionului din specia morun corelat direct cu temperatura apei, adâncimea de înot şi localizare geodezica precum şi indirect cu viteza medie de deplasare. Caracterul excepţional al prezentei lucrări rezidă din faptul că în Romania până în prezent nu a fost posibilă realizarea unei monitorizări a migraţiei sturionilor pe un numar însemnat de exemplare şi pe o distanţă de peste 400 km utilizând mărci ultrasonice.
Cuvinte cheie: Morun, *Huso huso*, migraţie, monitorizare, viteza de înot.

Introduction. The animal protein demand of the modern society records an upward trend (Lashkar boloki et al 2011), in this order fish products, especially sturgeons can play an important role. There are reports that in fish farming activities sturgeons are successfully raised in polyculture with European catfish (*Silurus glanis*) (Ünlü et al 2013).

Beluga (*Huso huso)* is one of the relic fish species (its origin comes from 195 million years ago) that populated Earth's waters (Muscalu & Muscalu 2009). This species belongs to the order entitled "*Acipenseriformes", "Huso"* genre, "*Acipenseridae"* family.

Beluga is a fish with a highly adapting capacity at temperature variations and salinity that carries out migrations in order to maintain its species, from the Black Sea, the Azov Sea and the Caspic Sea basins in river freshwaters (Niculescu 1959).

Meanwhile other species prefer to inhabit backwaters and canals, which serving as natural refuges, sturgeons prefer migration (Telcean & Cupşa 2009).

According to previous researches (Manea 1980) beluga's entrance in Danube usually occurs in the years with gentle winters, from January, the maximum period being recorded for April-May, and the spawning activity taking place in the same spring, in areas with deep waters, under temperatures of 15-17°C. Kabir et al (2011) shows the highest sperm movement and motile sperm percent for the same period (March-May) in Persian sturgeon (*Acipenser persicus*). Manea (1980) also confirms the existence of a second migration period, the fall one that begins at the end of July beginning of August and reaches a maximum in October-November. The individuals from this period are younger, less in number, with smaller waist and less formed sexual elements.

Water's low temperatures block spawns' ageing, the fish remaining in the deep waters. The process continues in the coming spring when the individuals that had wintered already are being pushed by the new ones in order to continue the breeding process (Manea 1980).

Antipa (1909) in his "Romanian ichthyologic fauna" paper mentioned that these depths are placed after angles, where water-course beats the shores and the feeding areas.

Tulcea's Danube Delta National Institute for Research and Development, currently a subunit of the National Institute for Research and Development in Environmental Protection tagged in November 2009, within a Romanian-Norwegian program to study sturgeons' migration routes, a number of 4 beluga individuals with ultrasonic tags.

One of the individuals wintered upstream km 42 Borcea Branch and has been recorded in May 2010, heading towards the sea in two locations: km 40 Borcea Branch and km 106- Sfântu Gheorghe.

A second beluga individual has been recaptured upstream km 40 Borcea Branch, in April 2010 and used for the artificial breeding. Moreover it has been tagged with a satellite tag from which signals have been received from the Black Sea. Romanian-Norwegian project's efficiency on the monitoring problem has en efficiency of 50% and the data obtained have an informative character because it is not statistically representative (total no. of sturgeons: 4).

During Tulcea subunit's researches, 40% of the sturgeons' reception automatic stations have been lost, along with the informational volumes. In order to protect this species, thoroughness studies are necessary to indicate the migration routes on the Lower Danube and to identify sturgeons' new breeding habitats and spawns' wintering and feeding habitats. One must protect and implement pre-emptive solutions in order to eliminate species' risk of extinction.

Currently there is an important researching campaign going on, regarding sturgeons' monitoring activities whose partial results are presented in this paper, in which 25 beluga individuals, tagged with ultrasonic and "anti-poaching tags" on the Danube sector, within km 175-375 during the fall migration are under supervision.

Material and Method. Sturgeons' migration tracking on the Lower Danube, within km 173-375 has been possible using the acoustic telemetry, ultrasonic tagging and reception stations, placed in areas of interest. This method is also described by Pfleger Institute of Environmental Research (www.pier.org). The sturgeon that is about to be tagged is being introduced in an operation tube, that allows to anaesthetize them through electro narcosis and tags' implantation.

Once the fish introduced, the tube will be connected to an electro narcosis device and the fish will be awaited to calm. The anesthesia is important to reduce overstress, which regarding to Caipang (2012) can initiate unnecessary process like antibacterial activity, inflammation, metabolism and antioxidant defense. Before the tag's introduction in the ventral cavity a local anesthesia with lidocaine will be made. Once the ventral cavity opened, using a blank bistoury the monitoring ultrasonic tag is being introduced and the incision is sutured in 3-4 points, using operating needle and suturing filament.

In order to clean the area one must use spray with terrafungine. In the end, the tag of "anti-pouching" T-bar type is being placed on the dorsal flipper, with a special pistol. The phases are described by Badilita (2012) (Figure 1). This minimal invasive

tagging method it is in concordance with other researchers' methods (Kabir & Bani 2011) in order to avoid needless trauma.

Figure 1. Phases of the sturgeon tagging process.

Before the release, biometric measurements are being carried out (total length, standard length, weight). The sex is being determined with the endoscope and a DNA sample is taken for analysis. All data are written on an exclusive capturing file, being introduced in a data base.

As for the submersible reception stations, used to record sturgeons' movement from the areas of interest, a new localization system has been used, developed by the researchers of the National Institute for Research and Development in Environmental Protection, entitled "DKTB station to monitor ichtyofauna and sturgeons through remote-sensing with ultrasonic tag, in different hydrological conditions".

This system is recorded at the State Office for Inventions and Trademarks with the number of A100773/2012, being composed of: metallic protective bonnet ø 15-20 cm, with special closing system (1), protective barrel ø 10-15 cm, having gaps to allow water to pass (2) and bridles to shore anchorage (3). Within the system, the reception station of the signal emitted by the ultrasonic tag, associated with the tagged, is being installed.

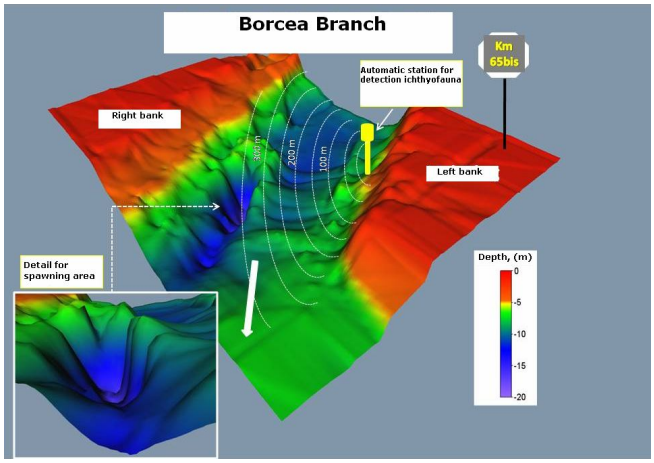

Figure 2. Localization of a reception station.

The system is placed on the shore area at a depth of about 2-3 m, after the bathymetric measurements had been made in order to indicate an area with fine bed, without any deep holes that could screen the signal transmitted by the tag.

In the area where Danube's width is bigger than 600 m a reception gate is being created, with 2 systems placed on both shores so that the signal emitted by the ultrasonic tag could be caught by at least one of the 2 stations. Figure 2 presents the localization of a reception station in river's bed after the area's analysis.

Before adopting this system another two have been applied, after their efficiency had proved to be low, because of the reception stations' loss and by default data's loss, the long period of time and high costs to recover and download them. The first system was composed of a weight of 90 kg, placed on the channel, metallic cable connected to the shore and enclosure with the reception station, whereas the second one needed the use of an anchor from which 60-100 m of textile line has been connected. At its bottom an enclosure with the reception station of the ultrasonic tags has been attached. The recovery of the stations and data interpretation has been made from a vessel using a mobile anchor to introduce and beat out the system out of Danube.

Periodically all the submersible automatic stations have been removed from water in order to extract the recorded data and then relocated in the initial positions.

Next to the date and the hour at which the fish passed through the monitored area each tag have 2 more sensors that offer information regarding the temperature and the depth at which the fish was swimming.

By data processing, information is being gathered, correlating water temperature to swimming behavior at different depth in fish migrating periods.

Results and Discussion. The results of this paper represent a part of a researching project entitled: "Monitoring the environmental impact of the works regarding the improving of the navigation conditions on the Danube River between Calaraşi and Brăila, km 375-175" that is being carried out within 2011-2017, being coordinated by the National Institute for Environmental Protection in Bucharest, Romania.

Within the fall migration monitoring campaign (October, November and December 2011), on the Lower Danube, between km 175-375, a number of 25 beluga individuals has been caught (1st fall campaign), using ultrasonic and "anti-pouching" T-bar tags.

Figure 3 graphically presents the percentage distribution of the captures within these 3 campaign months. In October the percentage of the captures has been of 8%. This fact is due to the fishing activities that started no earlier than at 10th October 2011 as well as to the low Danube levels. Manea (1980) concluded that there is a direct relation between Danube's level and the quantity of sturgeons fished on Sfântu Gheorghe Branch. The big number of individuals from November can be associated to the maximum period of migration from 2011. In December the percentage dropped until the value of 20%, caused by the water's low temperature, slowing down fish metabolism and hence, their movement.

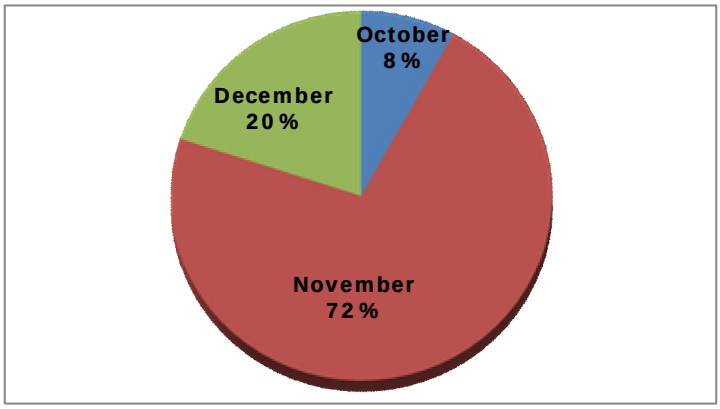

Figure 3. Percentage distribution of the individuals, on fishing months.

In order to monitor sturgeons' migration on the Lower Danube (km 175- 375) 17 automatic submersible stations have been placed in points of interest. Within October 2011-February 2012 these stations recorded beluga's presence in 7 of the locations. In order to capture beluga individuals that were about to be tagged with ultrasonic tags, fishing points have been established on Danube Branch, Caleia Branch and Borcea Branch.

Figure 4 presents the locations that recorded the individuals and each weight from the total accomplished. Borcea branch is subdivided in 4 areas, having the highest number of caught individuals. Therefore, this branch is one of the most important ones in beluga's migrating route.

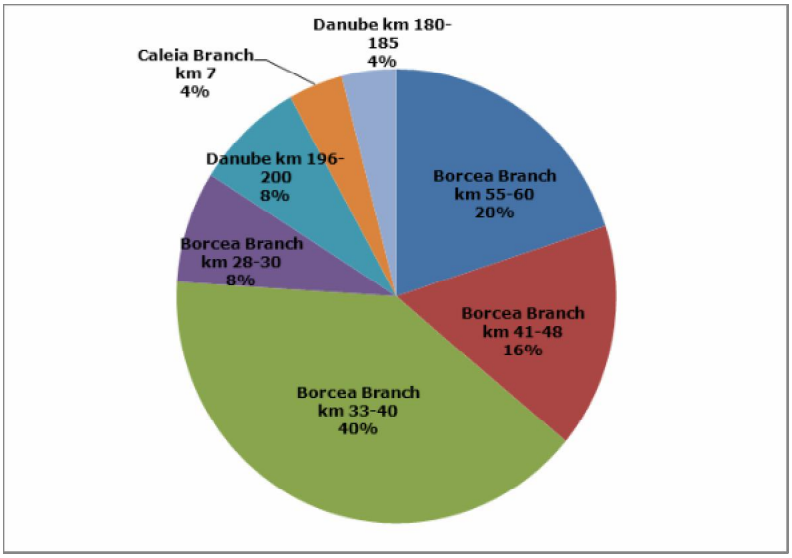

Figure 4. Percentage distribution of the caught sturgeons in fishing areas, in the fall campaign.

All the 25 beluga individuals caught and tagged in the analyzed period balance a total weight of 2,560 kg, with an average of 106 kg/individual. The average length of each individual has been 209 cm. The gender distribution has been: 92% males and 8% females. The variation interval of the length is 160-255 cm. Figure 5 presents the corelation between length and weight.

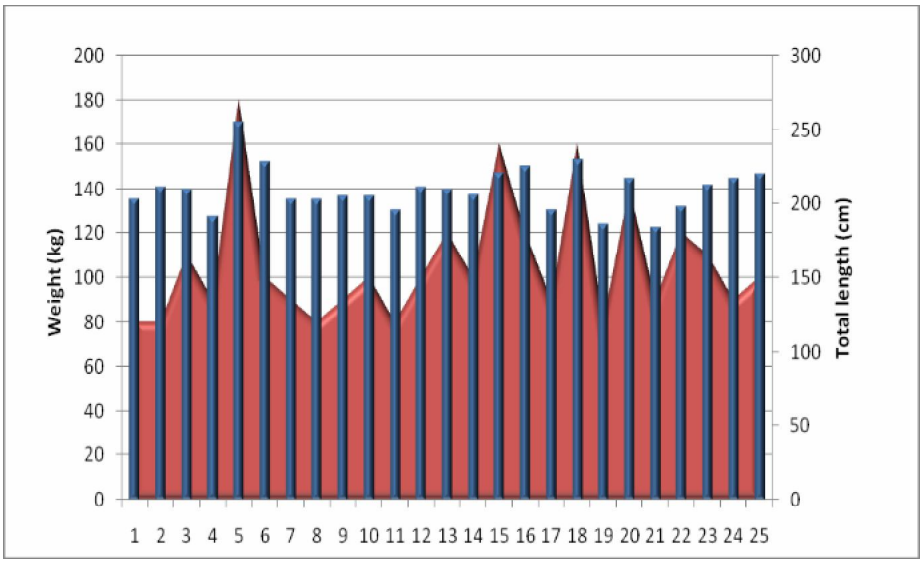

Figure 5. Corelation between length and weight of the caught beluga individuals.

Out of the tagged sturgeons, 80% have been recorded at least once by the stations placed on the monitored section, the rest of them being poached. At the end of November, 20% of the recorded individuals came down on Danube's course, lower than km 175, being detected by a controlling station, at km 100, Danube Branch. The explanation would be that during the cold season these remained somewhere near the discharge in the Black Sea.

Figure 6 presents sturgeons' capturing areas, the releasing ones and the areas where submersible automatic reception stations have been placed, on the Danube monitored sector.

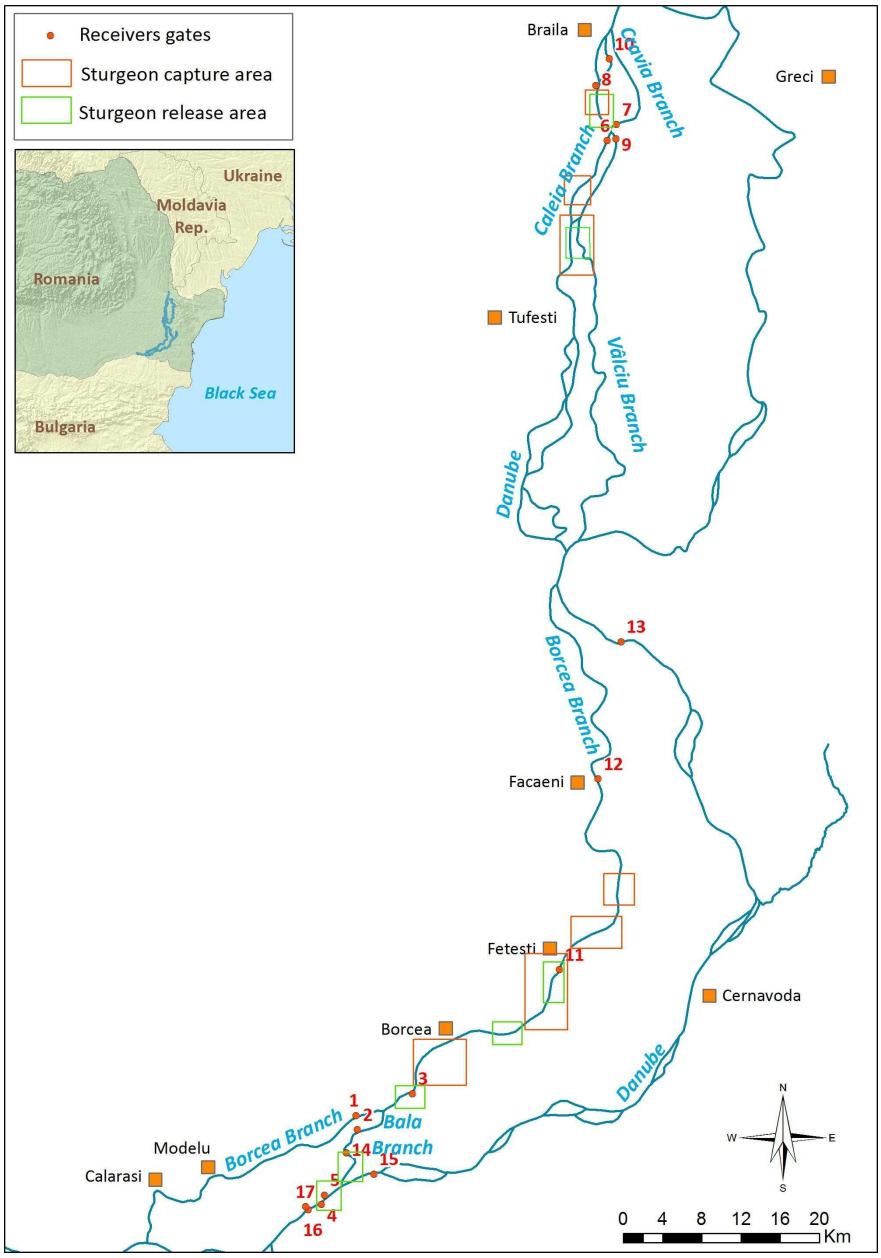

Figure 6. Beluga's capturing and releasing areas as well as automatic reception stations.

The followings will emphasize behavior aspects at 6 beluga individuals with ultrasonic tags, during the second migration (in the fall). Each beluga has a unique name, the same with the recording file number.

On November 9th, 2011 a beluga male, weighting 80 kg, has been caught, tagged with ultrasonic tag and released at km 43, on Borcea Branch. The identification code after

the accomplishment of the recording fiche was of 2S18. Its behavior during November consisted in coming down on the river course, the last recording being on the Old Danube, at km 180. The distance carried out made between the reception stations on the monitored section was of about 110 km. The recorded speed has been 13.8 km/day. Figure 7 presents the route made by this sturgeon, according to the obtained records. Within this period the water's temperature has been 7.2°C.

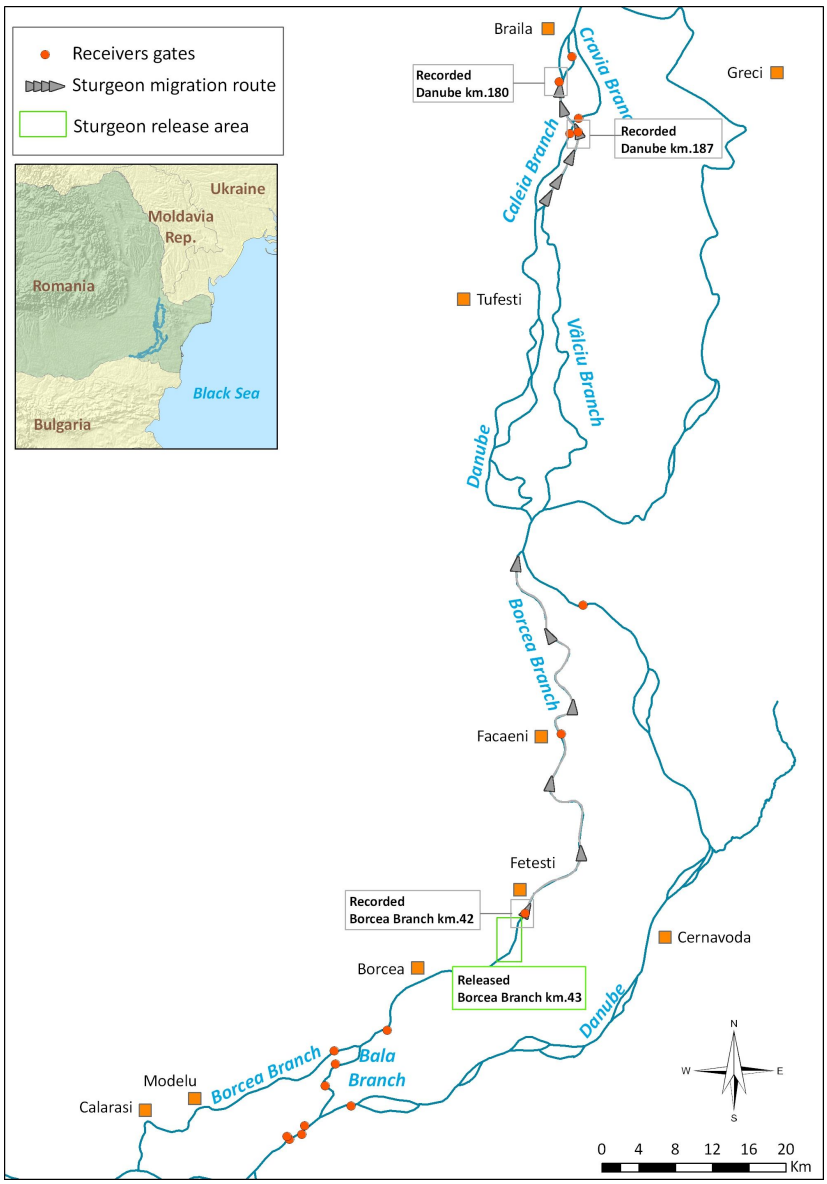

Figure 7. Migration route of beluga no. 2S18.

The lowest swimming depth has been recorded on Borcea Branch (2.43 m), whereas the highest one on Danube (13.9 m) (Figure 8).

Considering the fact that the most recent recordings have been noticed at the border of the monitoring area one cannot assume that the wintering of this individual took place downstream of the monitoring area or within it. The control station, placed at the km 100 Danube Branch, did not receive any signal from this sturgeon. In order to breed it has been spotted in the study area, at the end of April, when the water's temperature reached 14.4°C.

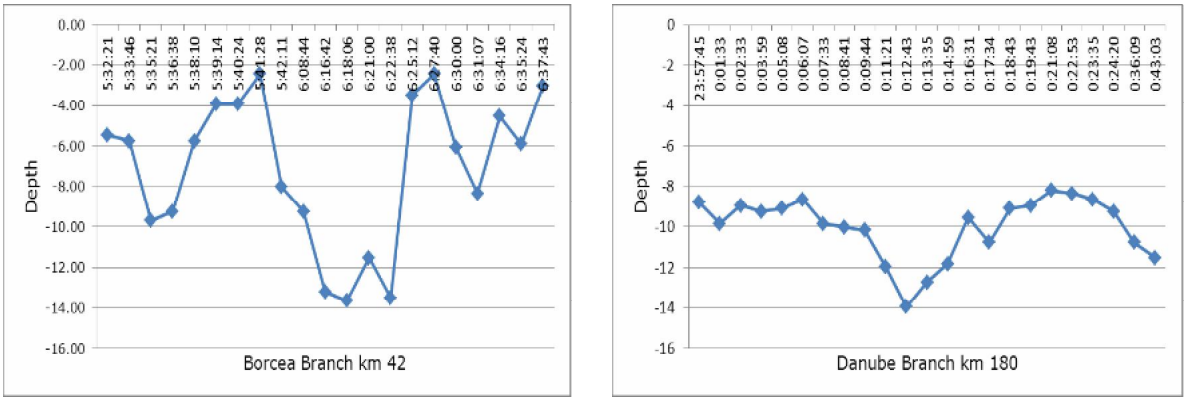

Figure 8. Beluga's swimming behavior (2S18) at Borcea stations (km 42), Danube (km 187), Danube (km 180).

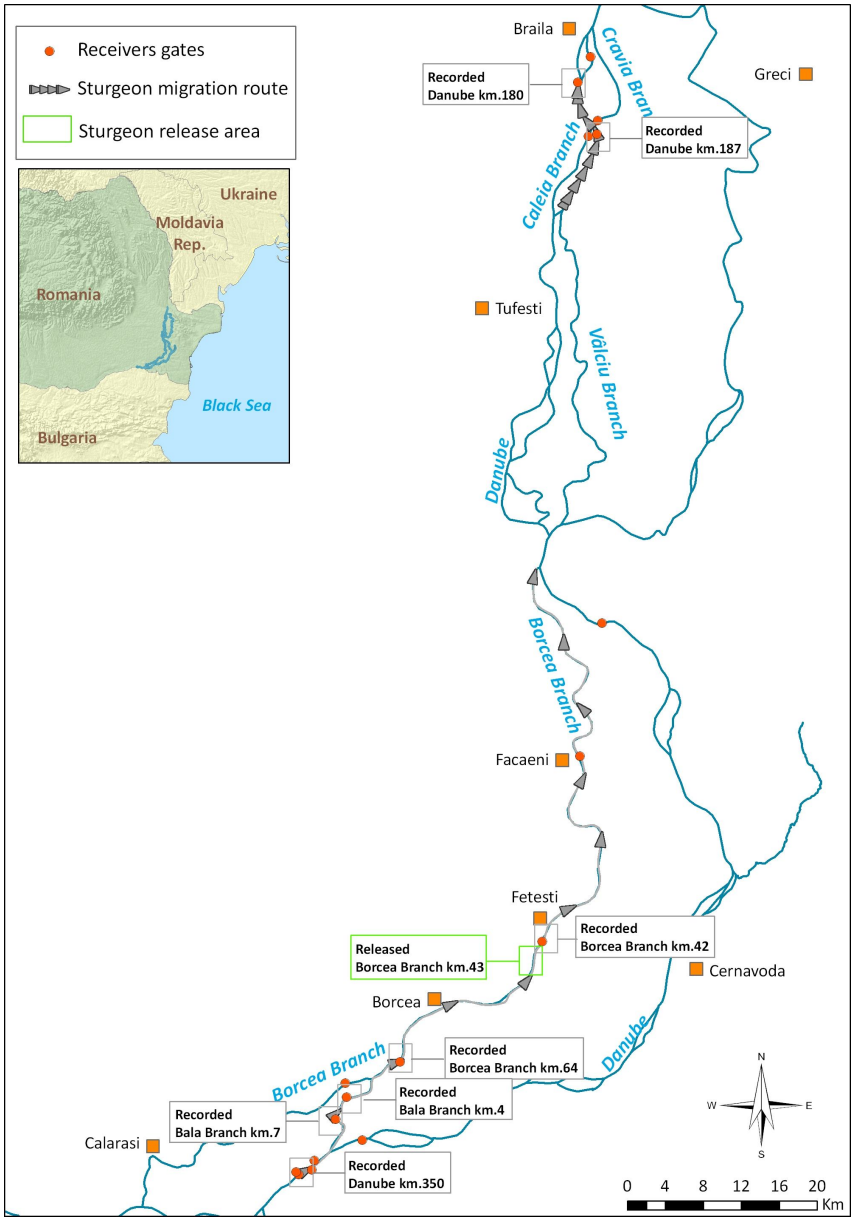

Figure 9. Migrating route of beluga 2S20.

Another individual (2S20) has been caught the same day, on November 9th, 2011 and within the same area as the previous one, yet at different wee hours. For this reason we assume that they walked together on river course. After tagging, the release of the male individual, weighting 100 kg has been made at km 43, on Borcea Branch. Sturgeon's behavior in the next period oscillated through swimming both upstream and downstream the monitored area. The initial purpose is to ascend, the individual being accidentally caught by commercial fishermen, at km 48 Borcea Branch. From here it comes a descending until km 30 Borcea Branch and then another ascent up until Old Danube Branch, at km 350. The following descent has been made on a distance of about 151 km until the Danube Branch (km 180), until its final recording. The migration route of this sturgeon is presented in figure 9.

Following the swimming depths, both during ascending and descending processes, on river course, in the area of submersible automatic reception station (km 64-Borcea) we can notice that the average of the swimming depths at ascending is of 11.75 m and of 5.8 m at descending (Figure 10). During the descending process the beluga swims closer the water surface because the water course is stronger and therefore the movement velocity rises.

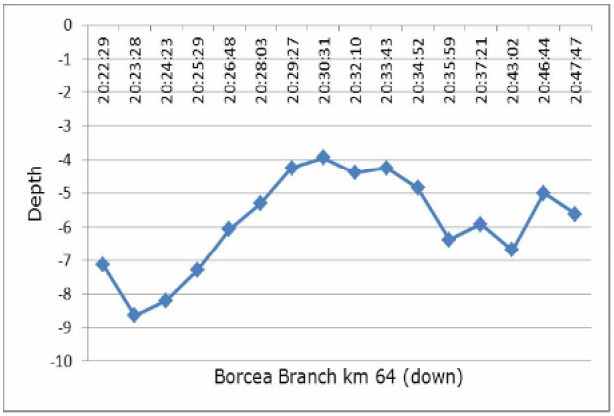

Figure 10. Swimming behavior of beluga 2S20 in the Borcea station (km 64) area, ascending and descending the river course.

In December 3rd, 2011, when the sturgeon has been recorded descending from the area of Danube Branch station (km 187) at the station from Danube (km 180), water's temperature reached 5.3^{o}C. Due to the lack of new recordings, cannot establish whether the individual wintered in the monitored sector or outside. The lack of recordings during spring time proves the fact that the breeding process might have been taken place downstream the monitored area.

In November 25th, 2011 a beluga individual has been caught, weighting 90 kg, with the identification code no. 2S27. Following the tagging process, was released in Bala Branch, km 8. From the data recorded at the reception stations, the swimming behavior of this sturgeon longs for downstream. On December 2nd, 2012 the individual reaches in the right of the reception station, on Danube Branch (km 180), after covering a distance of about 144 km, with an average velocity of 20 km/day. The migrating route is presented in Figure 11.

Water's temperature reached 5.2^{o}C. The lowest swimming depth (2.73 m) has been recorded in Bala area (km 4), whereas the highest (15.9 m) on Danube Branch (km 187) (Figure 12).

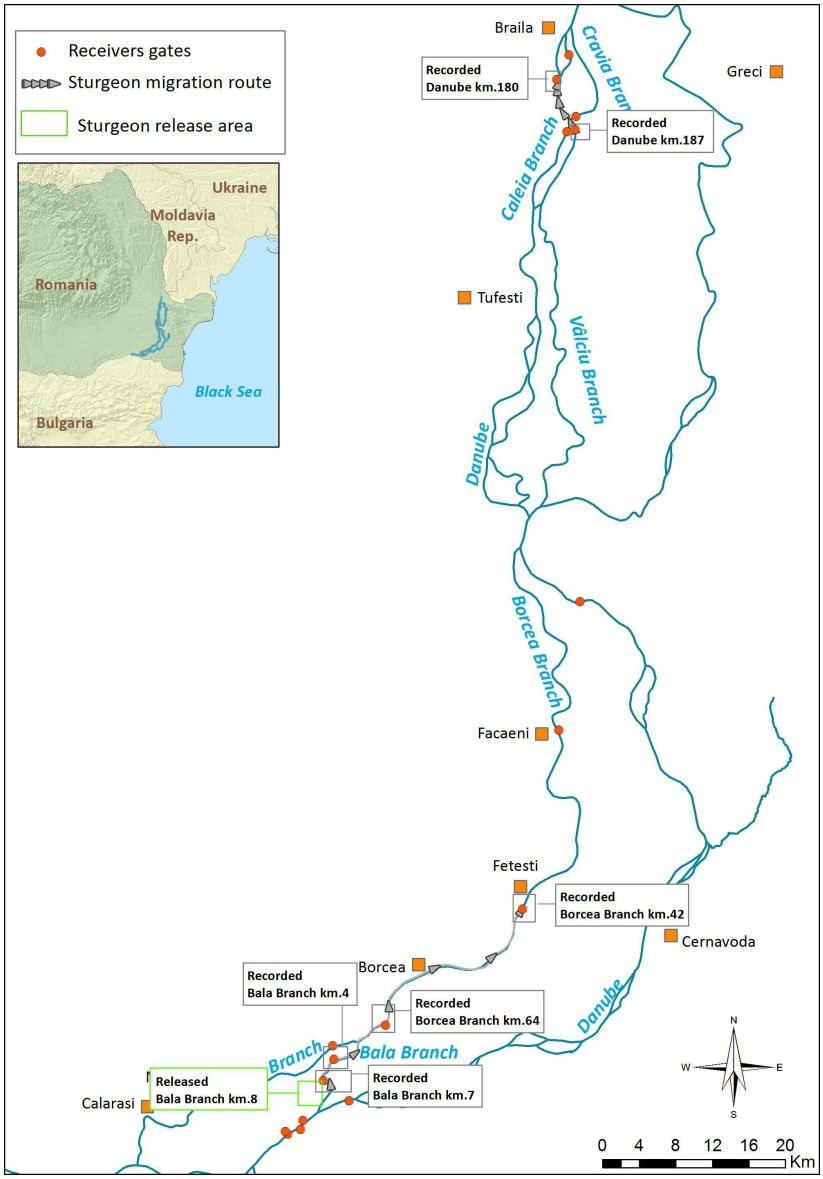

Figure 11. Migrating route of beluga 2S27.

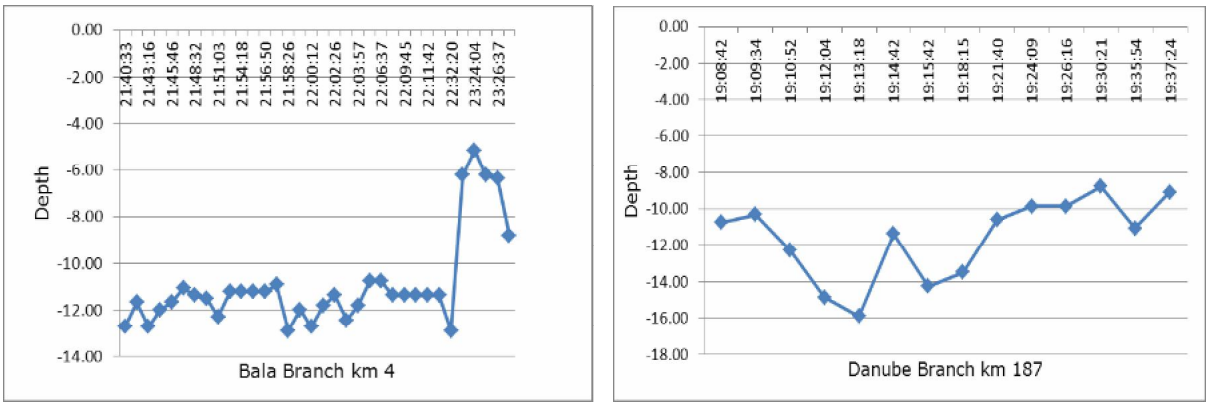

Figure 12. Beluga's 2S27 swimming behavior in the area of Bala stations (km 4) and Danube (km 187).

The sturgeon might have breed downstream the monitored area due to the lack of the recordings in the spring time.

On 26th November 2011 a beluga male individual, weighting 80 kg has been released at km 8, Bala Branch. The migrating behavior of this individual (2S29) is similar to the 2S27, maintaining the descending drive on river course. The last recordings come from November 2011, at km 42, Borcea Branch (Figure 13). In March new recordings appeared on Bala Branch, km 7, at the temperature of 6.1°C. In conclusion, during winter months the individual remained on Borcea Branch (km 42)= Bala Branch (km 7) sector.

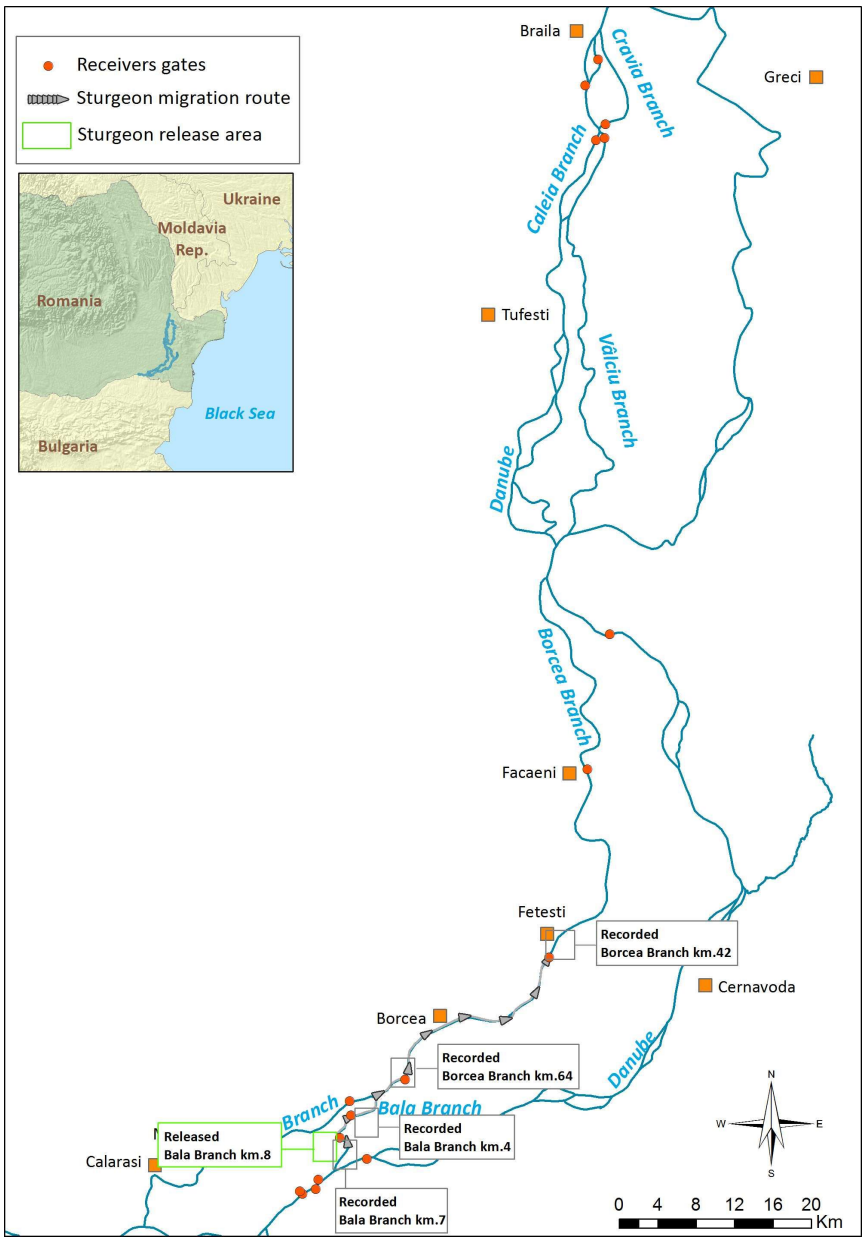

Figure 13. Migrating route of beluga 2S29.

On 7th December 2012 a beluga male individual has been caught, weighting 110 kg, with 2S33 identification code. This individual has been released on Bala Branch (km 8). During December 2011 - March 2012 this sturgeon has moved only on Bala Branch (km 7), Borcea Branch (km 64) sector. The numerous recordings of the reception stations also prove this fact. Interesting is the fact that in the first days of March the beluga presented an ascending behavior on the same sector mentioned. Yet, the temperature from this period reached then the frost level, of 0°C. Figure 14 presents the migrating route.

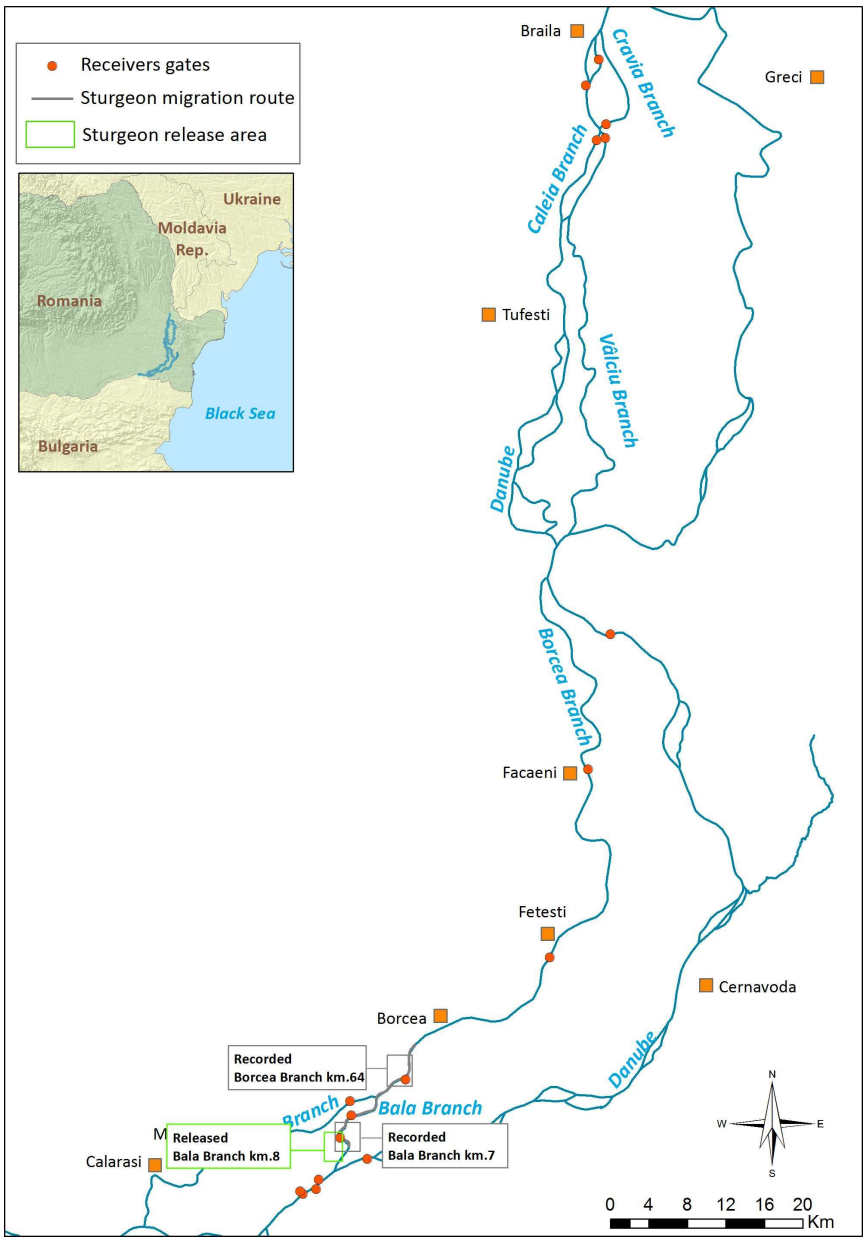

Figure 14. Migrating route of beluga 2S33.

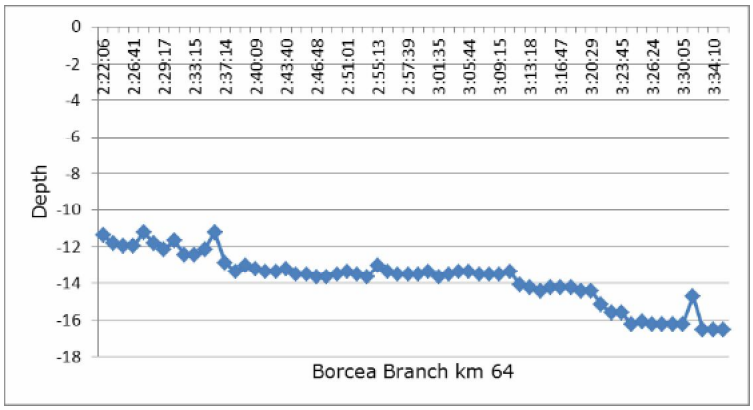

Figure 15. Beluga 2S33 swimming behavior at Borcea station (km 64) in Juanuary 2012.

Figure 15 presents in a detailed manner beluga's behavior on 23rd January 2012 in Borcea branch area (km 64) when the water's temperature reached 2.5°C.

For 70 minutes the minimum swimming depth reached 11.3 m and the maximum 16.5 m. The length of all recordings, cumulated with the small oscillations in water column represents a slow movement of the fish, in a quiet time.

2S37 beluga has been captured, tagged and released on 29th December 2012, on Bala Branch (km 9-10). Starting 30th December 2011 the stations' recordings started to present the descending behavior of beluga on river course, swimming in Borcea and Danube branches. Until 4th January 2013 it reached the limit of the monitored sector, that is Danube (km 180), covering a distance of about 150 km, with a medium velocity of 34 km/day (Figure 16). The swimming distance up to 100 km, covered by sturgeons looks like to be a normal phenomenon, given to other research which strengthens this statistics (Dionne et al 2013).

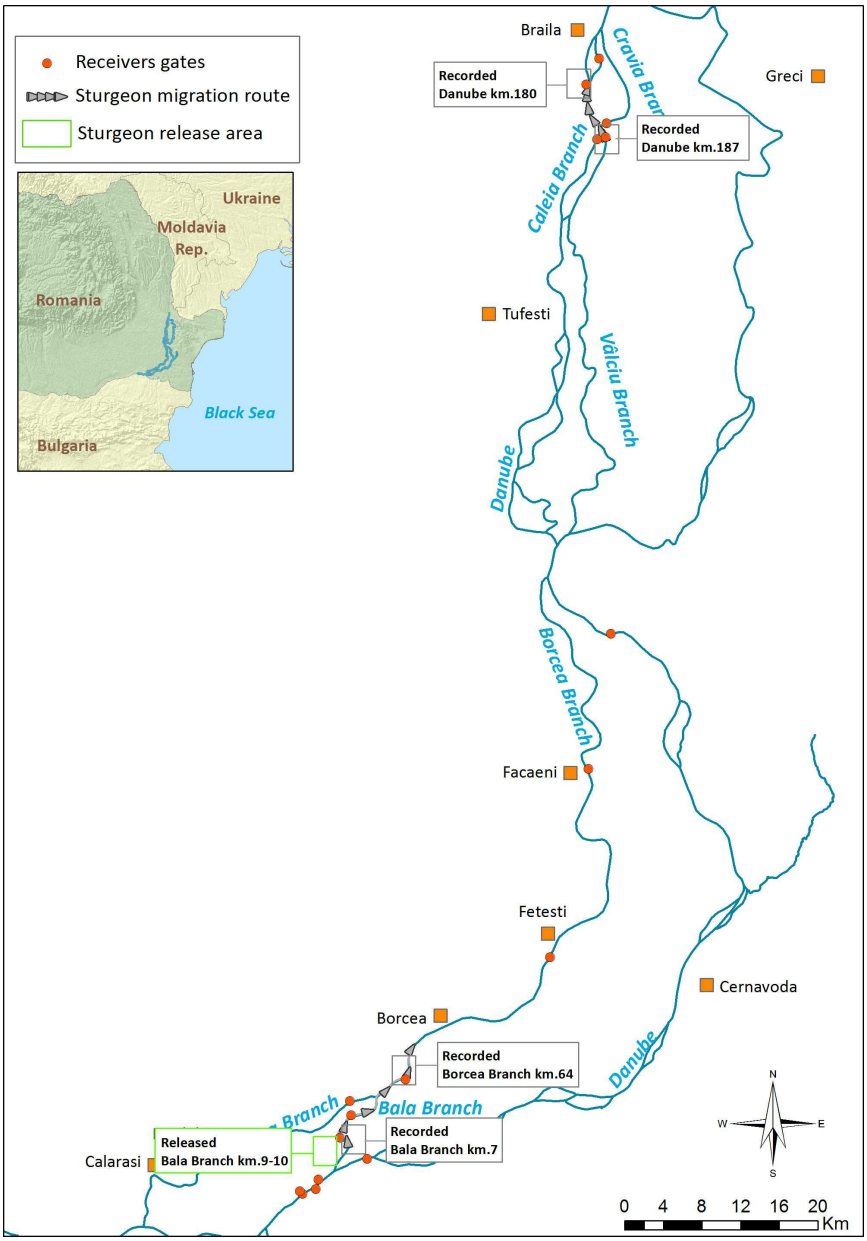

Figure 16. Migrating route of beluga 2S37.

Between the stations placed on Danube Branch at km, 187 and 180 the beluga had a medium movement velocity of 1.3 m/s. Figure 17 presents the oscillations of the deep

swimming during the descending among the two stations. The minimum swimming depth has been of 4.8 m and the maximum 21.2 m.

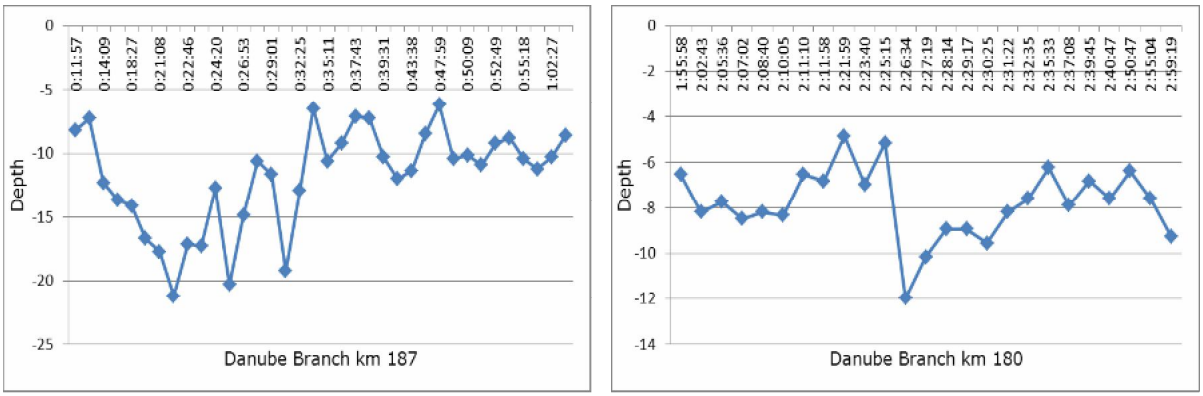

Figure 17. Beluga 2S37 swimming behavior in the area of Danube (km 187) and Danube (km 180) stations, during January 2012.

The average water's temperature in this period has been of 4.2°C. According to some authors the migration starts when the temperature reaches a minimum level of 4-5°C (Banarescu 1964). The more than 150 km covered distance proves this fact. Recent studies also conclude that this low temperature stimulate sturgeons reproductive activity (Muscalu et al 2010).

Conclusions. As other researchers (Szelei et al 2011) reported that statistical data's on sturgeons are a kind of poor, our studies came to enrich this scientific field.

The results of the caught sturgeons in the first fall campaign prove that the Borcea Branch represents a very important route in beluga's migration, on Lower Danube. This fact comes both from the high percentage of the captures made as a consequence of the scientific fishing (October-November 2011) and the recording of the submersible automatic telemetry stations. On Bala Branch fishing activities have not been organized yet the recordings that prove beluga's presence in the winter months confirm the existence of quartering areas, with deep areas.

Another important Danube migrating route is the one between km 180-187, through belugas' recordings that came down on river course until this area as well as the area upstream (confluence with Valciu Branch and Caleia Branch).

During the monitored periods the beluga individuals swim on the river course even on very low temperatures of 0°C. 2S33 beluga has been recorded at the beginning of March 2012 covering a distance of 11 km between Borcea Branch and Bala Branch, in order to probably feed itself.

There are some aspects regarding the swimming parameters at the individuals studied. The deep oscillations at fish in the first movement are higher than the ones that are idle.

The authors of this current study noticed the existence of a high pressure on the sturgeons, created by the pouching activities, aspect proven through the lack of information from some individuals ultrasonic tagged but also through the low percentage of the tagged females. In order to reduce this phenomenon, an informative campaign for all fishermen from the monitored area has been created, regarding the advantages of the researching activities on sturgeons' species. Another measure has consisted in the use of T-Bar type tags, attached by the flipper and entitled by us: "anti-pouching tags", that indicate the fact that the caught sturgeon is part of a researching program and it is used by us to offer information necessary to adopt some conservation measures. In this case fishermen are obliged to notify the monitoring team.

The new monitoring system method of the reception automatic stations of the ultrasonic tags, having the patent request with the no. of A100773/2012 has been

successfully used until now, without recording any other lost stations. Therefore, the data volume has raised and the maintenance costs have dropped.

For the future, this monitoring activity will go on, enriching the informational volume with other campaigns of sturgeons' ultrasonic tagging as well as more detailed investigations of the wintering and breeding areas.

Not at least as Lenhardt et al (2011) recommend, such data's can also be used to determine anthropogenic influences upon fish populations in a certain ecosystem.

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