„Dunărea de Jos" University of Galaţi
The School for Doctoral Studies in Industrial Engineering

PhD THESIS

ABSTRACT

Research on the monitoring of sturgeon populations by telemetry techniques in the Lower Danube sector of Brăila-Călărasi

Ph.D. student,
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Series I 4: Industrial engineering No.55
GALAŢI, 2019

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Table of Contents

INTRODUCTION

The economic importance of the Danube, mainly due to commercial transport routes, but also to water and food resources, has been recognized and appreciated since ancient times. The economic development of the society has been and will remain the priority of any riparian state, but in the last decades irrationality or disregard of the negative effects associated with the use of the Danube resources, have seriously affected the ecological integrity of the river. According to the National Management Plan, related to the national portion of the international river basin of the Danube River, the interruption of longitudinal connectivity following the development of certain hydro technical constructions, overfishing and water pollution have gained an unprecedented rise in the last 50 years [1]. Regarding sturgeons, because in the year of 2006 all species from the Lower Danube basin were in a poor state of conservation, the Ministry of Agriculture, Forests and Rural Development together with the Ministry of the Environment initiated the Danube Repopulation Program with sturgeon specimens, by Common Order 262/330 of 2006 on the conservation of wild sturgeon populations in natural waters and the development of sturgeon aquaculture in Romania [2]. The legislative act provided, in addition to the establishment of special measures for the development of sturgeon aquaculture, also the temporary prohibition of fishing for commercial purposes for a period of 10 years. As a result of the repopulation, the number of specimens that arrived in the Danube increased from about 4,900 in 2005, to over 100,000 in 2009, according to the National Management Plan for the national portion of the international river basin of the Danube River, data that does not have a level of high confidence.

In 2016, the period of prohibition of commercial fishing was extended by another 5 years, by Order no. 545/715/2016 regarding the measures of restoration and conservation of sturgeon populations from natural fish habitats [3], without an evaluation of the 10 years prohibition effectiveness.

It is not yet exactly known whether these measures have significantly contributed to the restoration of the species conservation status, respectively if they are facing the pressures with negative impact on sturgeon populations.

For a full assessment of the sturgeon species conservation status of the Lower Danube, respectively, to lay the basis for efficient and sustainable management, scientifically well-grounded data are required on the nature and effect of anthropic pressures on populations. Research has a fundamental role in the assessment of stocks, the study of the species specimens' behaviour and the identification/analysis of pressures with a significant negative impact on the conservation status of the species. For these reasons, the Ph.D. thesis entitled ***Research on the monitoring of sturgeon populations by telemetry techniques in the Lower Danube sector of Brăila-Călărași*** aims to study the impact of anthropic pressures on the conservation status and migration routes of sturgeons in the Lower Danube.

The main objectives of the thesis are:

- Evaluation of the general and specific behaviour (overcoming a submerged obstacle) of the tagged sturgeons in the Lower Danube

- Analysis of the biometric characteristics of tagged anadromous sturgeons
- Creating maps containing the migration routes of tagged sturgeon specimens
- Analysis of the impact of anthropogenic factors (bottom sill km 9.7 Bala and poaching) on the migration and conservation status of tagged anadromous sturgeons

The doctoral thesis is structured in 7 chapters. The first two chapters present the state of the art in the field, both in terms of the existing sturgeon species, as well as the ways of tagging and monitoring the specimens, used along the years worldwide. The other chapters present the activities and results obtained from analysing the behaviours of a number of 300 specimens of anadromous sturgeons tagged with ultrasonic tags from the Lower Danube. Capture, ultrasonic tagging, and release of the sturgeon species specimens presented in the doctoral thesis were possible following the scientific fishing, authorized according to the law. The data presented, obtained by own contribution and with the help of the INCDPM research team, led to the improvement of the monitoring techniques and to the improvement of the information volume regarding migration routes, sturgeon behaviours and the impact of anthropic pressures on species conservation status.

In this way, the author of the doctoral thesis would like to thank the colleagues from INCDPM for efficient collaboration during 7 years of in situ campaigns, with the help of them a unique database has been obtained regarding the behaviour of the ultrasonic tagged sturgeons from the Lower Danube.

CHAPTER I GENERAL CONSIDERATIONS CONCERNING STURGEONS

Over time, sturgeon species have undergone only a few morphological changes, their evolution was very slow, hence the name "living fossils" [4]. Survival over such a long period is due in part to tolerance to different temperatures and salinity, lack of predators, the abundance of food specific to the benthic environment in which they spend most of their life and their adaptability, demonstrated over time. However, lately sturgeon species around the world have experienced massive decreases in numbers [5]. This decline may be the result of hydro constructions, overfishing and pollution of the aquatic environment with a direct impact on sturgeon migration and reproduction. Therefore, the main factor with a negative impact on the wild populations is the social-economic development of the human communities that led to the degradation of the environment in general, having as significant indicators: pollution, overexploitation of natural resources and modification of hydro morphological parameters.

Sturgeons are found only in the northern hemisphere of Earth. Half of these species are found in Europe, one third in North America and the rest in East Asia and Siberia [6].

1.1 Taxonomic aspects, morphological and biological characteristics of sturgeons

Sturgeons are species of the ancient family *Chondrosteidae*, with continuity from the Triassic (245 - 208 million years ago) to the order of today's *Acipenseriformes* [7]. At the current level of knowledge, according to Fish Base (the database with the most comprehensive inventory of ichthyofaunal in the world), the accepted classification indicates sturgeons as species of the order *Acipenseriformes*, which belongs to the class of

Actinopterygians and comprises two families: the family *Acipenseridae* and the family *Polyodontidae* [8].

The family *Acipenseridae* comprises 25 species divided into 4 different genera [9], Figure 1.1, as follows:

- the genus *Acipenser* with 17 species;
- the genus *Huso* with 2 species;
- the genus *Scaphirhyncus* with 3 species;
- the genus *Pseudoscaphirhyncus* with 3 species.

The *Polyodontidae* family comprises two genera (*Polyodon* and *Psephurus*), each of them containing a single species *Polyodon spathula* and *Psephurus gladius* [10].

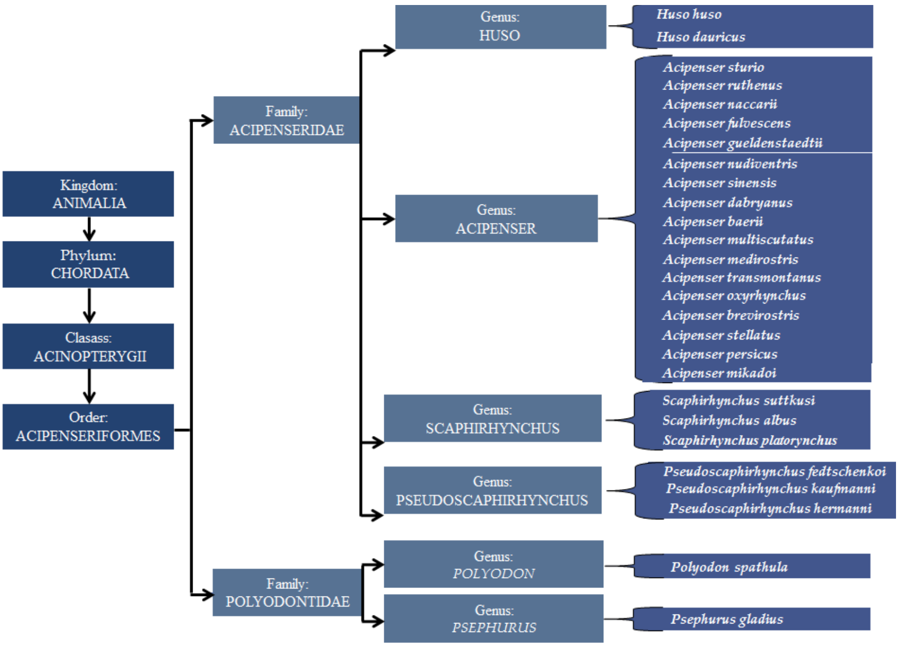


Figure 1.1 Sturgeon taxonomy [11]

Sturgeons are long-lived fishes with late-maturing, all species spawn in fresh water, most of them are anadromous. The morphology of the sturgeons is represented by the elongated, fusiform body. The outside part of the body is composed of five rows of longitudinally arranged bone plates, a dorsal row, two lateral and two ventral, all of them forms a kind of external skeleton, specific to prehistoric animals (Figure 1.2) [12].

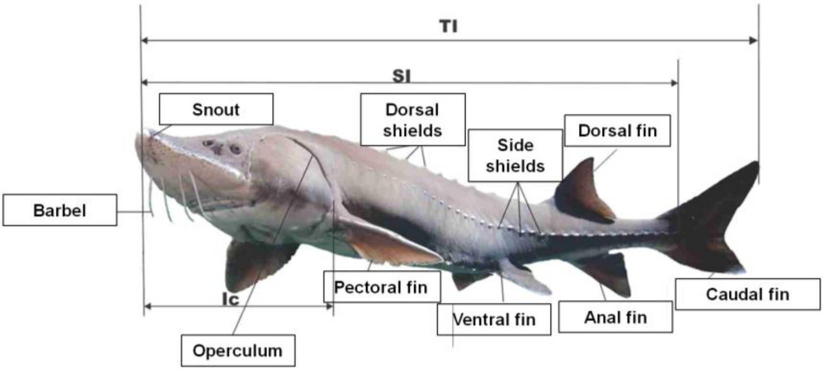


Figure 1.2 Sturgeon morphology [13]

The main morphological characteristics of the sturgeons, shown in Figure 1.2, are as follows:

Tl = total length

Sl = standard length

lc = head length

1.2 Distribution of sturgeons around the world

From the specialized literature, sturgeon habitats are identified in:

- **Euro-Asian area** - in the Mediterranean basin, in rivers (Danube, Dniester, etc.) that flow into the Black Sea, the Azov and the Caspian, into the rivers of northern Russia and the rivers that feed the Arctic Ocean. [11].

- **North America -** Sturgeon habitats extend along coasts of the Atlantic Ocean from the Gulf of Mexico to Newfoundland, including the Great Lakes and the San Lorenzo, Missouri and Mississippi rivers, in the rivers and lakes of south-eastern Canada, South Dakota, Oklahoma, on the coasts of New York and Washington. Sturgeons are also present in the rivers on the West Coast, in the area of California and up to the area of British Columbia [11].

- **Asia** – sturgeons are found in the Amur River on the Russian-Chinese border, Sakhalin Island, Yangtze River, along the coasts of Japan, Taiwan, Hainan and other rivers in northern of China [11].

1.3 Conservation status of sturgeon species

According to IUCN, sturgeons are the most threatened species living in the world. All 27 species of sturgeons are on the IUCN red list, and 17 of them are considered critically endangered (Table 1.1).

Table 1.1 Conservation status of sturgeon species worldwide

SPECIES	Concerned	Threatened	Vulnerable	Endangered	Critically endangered
Huso huso					
Huso dauricus					
Acipenser baerii					
Acipenser brevirostrum					
Acipenser dabryanus					
Acipenser fulvescens					
Acipenser gueldenstaedtii					
Acipenser medirostris					
Acipenser mikadoi					
Acipenser multiscutatus					
Acipenser naccarii					
Acipenser nudiventris					
Acipenser oxyrhynchus					
Acipenser persicus					
Acipenser ruthenus					
Acipenser sinensis					
Acipenser stellatus					
Acipenser sturio					
Acipenser transmontanus					
Scaphirhynchus albus					
Scaphirhynchus platorynchus					
Scaphirhynchus suttkusi					
Pseudoscaphirhynchus fedtschenkoi					
Pseudoscaphirhynchus hermanni					
Pseudoscaphirhynchus kaufmanni					
Polyodon spathula					
Psephurus gladius					

According to IUCN Red List

At the international level, very little is known about the habitats and behaviour of sturgeons in certain situations, especially those involving hydro morphological changes of the riverbed of the river in which they migrate for spawning. There are research studies developed lately in this direction, many in the USA, but also at the national level, such as the one carried out by INCDPM, in the period 2011-2019, which have had as one of the results a unique database with information regarding of sturgeon species from the Lower Danube [14].

CHAPTER II CURRENT STATUS ON TAGGING AND MONITORING OF THE STURGEONS

The monitoring of ichthiofauna was carried out in the past for "Detailed knowledge of the trips made by the fish at different times of the day or periods of the year, especially demanded by the needs of industrial fishing in seas and oceans". The monitoring of ichthyofauna was carried out in the past for "Detailed knowledge of the trips made by the fish at different times of the day or periods of the year, especially demanded by the needs of the development of industrial fishing in seas and oceans" [15]. However, the study of the fish migration is no longer limited only to understanding the periods and migration routes in order to increase catches and develop fishing techniques. Currently, research is being done in order to identify factors with a negative impact on the phenomenon of migration and the most appropriate measures for the conservation of species and habitats, given the sustainable development with a strong focus on the environmental protection component.

Regarding the methods of fish tagging, for monitoring purposes, they are classified into three categories: biological, chemical and physical.

2.1 Tagging techniques and methods used worldwide

The use of ultrasound tags in research studies of ichthyofauna has started in the last decade, in general for understanding the behaviour and for monitoring the fish migrations, both in the natural environment and in aquaculture [16]. Tagging of specimens of the sturgeon species is done in order to identify and establish certain considerations regarding migration routes, population appreciation, and behaviour analysis in certain situations such as those involving hydrodynamic variations, etc. The ultrasonic tag can be attached to the specimens outside or inside the body, usually in the abdominal cavity (Figure 2.1).

Figure 2.1 Ultrasonic tags

Subsequent monitoring is carried out by identifying the signals emitted and detected by receivers located in the aquatic environment. The advantages of this method of tagging are:

- the possibility of choosing the tags according to the size of the specimens, so that the growth and subsequent development is not affected;
- placing the tags in the body of the specimen and reducing the risk of attracting predators;
- a higher number of specimens that can be tagged as well as an easier identification;
- the possibility of knowing certain information regarding the behaviour of the specimen in the aquatic environment, without the need to recapture.

Among the main disadvantages of this type of tagging, it can be listed:

- poor efficiency of monitoring in waters with abundant vegetation or high turbidity, as they may perturb the detection of tags;
- the short-lived battery of the tag.

2.2 Monitoring techniques used worldwide

Research study - Sturgeon monitoring in Ship Island, Gulf of Mexico

The gulf sturgeon (*Acipenser oxyrhynchus*) is a species listed in the U.S. Federal Register. since 1991 as a critically endangered. The total population is estimated, in the rivers that flow into the Gulf of Mexico, at 15,000 adult specimens. The number of specimens has been greatly reduced since the XX century, mainly because of poaching [17]. Figure 2.2 shows the range of golf sturgeon spread in the Gulf of Mexico area.

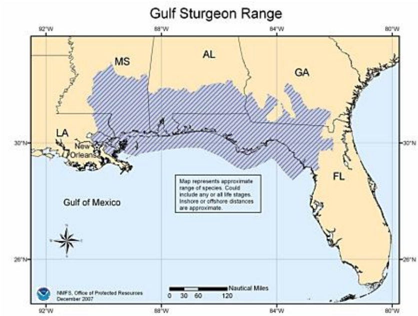


Figure 2.2 The range of the golf sturgeon in the Gulf of Mexico area [17] [18]

At present, efforts are being made to improve the conservation status of the species. Several research projects were developed in the Gulf of Mexico area, one of them in period 2011-2013, conducted by US Fish and Wild Services and the University of Southern Mississippi. The study had as main objectives:

- evaluation of the habitats of the species *Acipenser oxyrhynchus* in the Ship Island area, using acoustic telemetry;

- identifying the behaviour of sturgeon specimens through two different approaches:
  - coarse-scale evaluation, more precisely determining the frequency of occurrence of specimens in different areas of the monitored area;
  - fine-scale evaluation, respectively determining the behaviour of the monitored specimens [17].

For the monitoring of the ultrasonic tagged specimens, 21 monitoring systems of the type shown in Figure 2.3 were used, consisting of a small floating device, provided with a catch tube of the ultrasonic receiver and a weight with unspecified weight for anchoring, very similar with the Type I system, one of the systems used in the Danube.

Figure 2.3 System used for monitoring sturgeons [18]

CHAPTER III MATERIALS AND METHODS

In order to complete the thesis, the materials and methods were chosen or developed, based on the experience gained by the author through the implementation of several projects together with the INCDPM (National Institute for Research and Development in Environmental Protection), starting with 2011. The projects, in which the author of the thesis was part, have had as objectives:

- hydro morphologically monitoring of certain sectors in the Lower Danube,
- capturing sturgeons (including juvenile specimens), ultrasonically tagging mature specimens and releasing them into the natural environment for further monitoring,
- developing new methods and techniques for monitoring ultrasonic tagged sturgeons,
- assessment of the anthropogenic impact on sturgeon populations,
- permanent documentation, processing of data obtained with a unique character in the field, decisional and comparative analyses, correlative matrices of anthropic factors - biotic parameters and complex maps regarding the migration routes of ultrasonic tagged sturgeons.

Also, important additional results were obtained in the thesis, through own investigations or in teams with researchers from INCDPM.

3.1 Location of the study area

The fishing for scientific purposes was carried out on the sections related to the Borcea and the Caleia branches, between 2011 and 2017.

The location of the monitoring stations, necessary for the reception of the ultrasonic signals emitted by the tags inserted into the specimens, was carried out in the Lower Danube sector on the most important migration routes of sturgeons.

3.2 Procedure for tagging the captured specimens

The tagging procedure (between 2011 and 2017) refers to all the stages that required interventions on the specimens, from the moment of capture to their release in the natural environment, respectively:

- classification by species,
- determination of sex with ultrasound equipment,
- determination of length, perimeters and body mass,
- performing the surgical operation to implant the tag (ultrasound tagging),
- anti-poaching tagging,
- releasing the specimens.

3.2.1 Biometric measurements

Biometrics consisted of somatic measurements, respectively total length (cm), head circumference (cm), trunk circumference (cm), tail circumference (cm) and body mass (kg). Length and circumference measurements were made with the tape measure. Figure 3.1 shows images from the activity of biometric measurements.

Figure 3.1 Biometric measurements

3.2.2 Techniques and methods used to determine the sex of the specimens

To determine the sex of each captured specimen, using a non-invasive method, the WELLD WED 3000V ultrasound was used (Figure 3.2).

Figure 3.2 Sex determination of an Acipenser stellatus specimen

3.2.3 Description of techniques and systems used for sturgeon monitoring in the Lower Danube

The development of the new monitoring types of equipment was carried out over a period of 4 years, during which several attempts were made. Following is presented and characterized four systems of monitoring of ichthyofauna, of which two were patent by the author together with researchers from INCDPM. The systems were used in the period 2011 ÷ 2012, respectively from 2012 until now for the monitoring of sturgeons in the Lower Danube area.

The Type I system (Figure 3.3) was developed within the INCDPM-Tulcea INCDD Subunit and was used for sturgeon monitoring in the period 2011 - 2012. During 2012, due to the clogging of the cables, several receivers with the related information volume were lost.

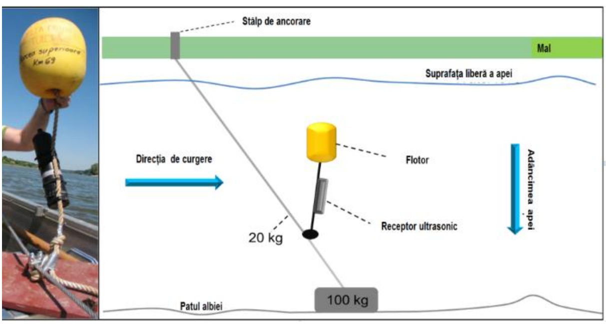


Figure 3.3 Type I monitoring system [19]

The Type II system (Figure 3.4) was designed by INCDPM in collaboration with INCDPM Subunit INCDD Tulcea and INCDPM Subunit INCDM Constanța and was used during the monitoring period between 2011 and 2012. Recovery of the receivers was made, after position identification, by hanging and removing the system with an anchor in order to download the logged data. The results of using the Type II System proved to be inefficient due also to the large loss of receivers.

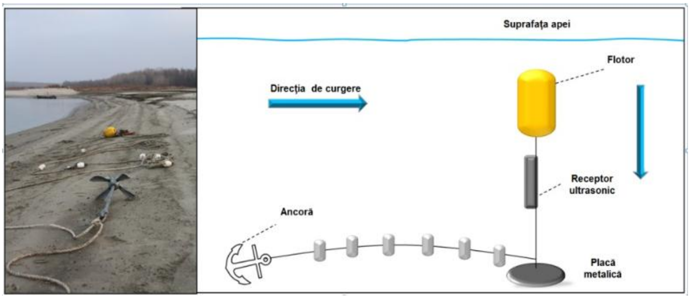


Figure 3.4 Type II monitoring system [19]

The type III system (Figure 3.5), called "Monitoring station for ichthyofauna, especially sturgeons under different hydrological conditions", was developed by the author together with the team of experts from INCDPM and used from 2012 to present.

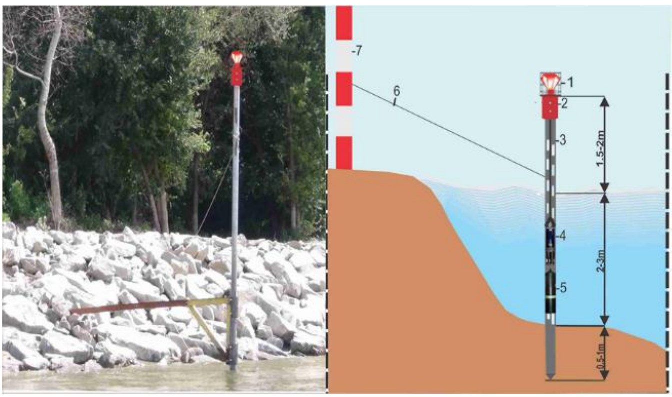


Figure 3.5 Ihtiofauna monitoring station and in particular of sturgeons under different hydrological conditions

The type IV system (Figure 3.6) refers to "*Floating monitoring station for monitoring sturgeons by remote sensing under difficult hydrological conditions*". The equipment has been used since 2013 and was developed by the author along with the INCDPM expert team.

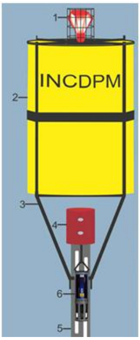


Figure 3.6 Floating monitoring station for monitoring sturgeons by remote sensing under difficult hydrological conditions

3.2.4 Comparative analysis of the 4 sturgeon monitoring systems used in the Lower Danube

To compare the performances of the four monitoring systems used in the studies of sturgeon migration, 6 decision parameters were utilized, that are presented in Table 3.1.

Table 3.1 Comparative analysis of the monitoring systems

System	Analysis parameter					
	Localization Precision	**Risk of data loss**	**Set-up effort**	**Data retrieve effort**	**Data retrieve costs**	**Manufacturing and maintenance costs**
Tip I	low	high	medium	high	high	medium
Tip II	low	high	medium	medium	high	low
Tip III	high	low	medium	low	low	low
Tip IV	high	low	low	low	low	medium

The type III and IV systems have the advantage of a low risk of loss of information volume, a small effort to download data and low costs for manufacturing and maintenance. The two equipment were patented at the State Office for Inventions and Trademarks (OSIM): RO 128559 and RO. 129 803.

In order to determine the exact position and behaviour of the sturgeons, if they were outside the detection area of the in situ stations, the Vemco VR100 telemetry monitoring receiver was used. The equipment, shown in Figure 3.7, is composed of a control device and a directional hydrophone connected directly by the cable. The device works by capturing acoustic signals between 50 and 85 Khz, emitted by the tags implanted in sturgeons.

Therefore, in certain situations, the monitored specimens have been located in real-time. For each detection have obtained: the date, time and GPS coordinates.

Figure 3.7 VR100 Vemco mobile telemetry equipment

3.3 Equipment used to study the morphology of the riverbed

3.3.1 MULTIBEAM

The Kongsberg GeoAcoustics GeoSwath Plus 250kHz system (Figure 3.8) is designed for digital topographic mapping (DTM), for water depths up to 200 m. The accuracy of the measurements made with this equipment is in accordance with the *IHO Standers for Hydrographic Surveys, Special Publication 44* [20].

3.3.2 SINGLEBEAM

To determine the water flow and velocity in different sections, two equipment were used:

- SonTek River Surveyor M9, which is a robust and extremely precise measuring system, specially designed to measure, with the help of Doppler technology, bathymetric profiles, water flow and velocities;
- The River Ray system is designed to measure water flow and velocities in real time and to provide bathymetric profiles of the section, using the ADCP technique (*Acoustic Doppler Current Profiler*), Figure 3.9.

Figure 3.8 MULTIBEAM equipment

Figure 3.9 River Ray and River Surveyer equipment

CHAPTER IV CHARACTERIZATION OF THE LOWER DANUBE STURGEON POPULATIONS

4.1 Lower Danube sturgeon species

With the exception of starlet all the other Black Sea sturgeons are anadromous fish [21], anadromous fishes are those that migrate upstream on the Danube River for spawning. The distance made during the migration process varies according to each species, from tens to hundreds of kilometres [22]. After spawning, anadromous sturgeons return to the Black Sea and again to the Danube after a certain period of time that varies by species between 3 and 5 years.

Acipenser gueldenstaedtii (Brandt & Ratzeburg, 1833) **– Russian sturgeon**

The Russian sturgeon (Figure 4.1) is an anadromous species found in the rivers that flow into the Black Sea, Azov and the Caspian (Figure 4.2).

Figure 4.1 Acipenser gueldenstaedtii

Figure 4.2 The range of populations of Acipenser gueldenstaedtii [23]

Acipenser stellatus (Pallas, 1771) **– Stellate sturgeon**

The Stellate sturgeon (Figure 4.3) is an anadromous species found in rivers flowing into the Black Sea, Azov, Caspian and Aegean (Figure 4.4) [24].

Figure 4.3 Acipenser stellatus

Figure 4.4 The range of populations of Acipenser stellatus

Acipenser ruthenus (Linnaeus, 1758) **– Sterlet sturgeon**

The Sterlet sturgeon (Figure 4.5) is a freshwater species, found in the rivers of the Black Sea, Azov, Aegean and Caspian basins (Figure 4.6) [26].

Figure 4.5 Acipenser ruthenus

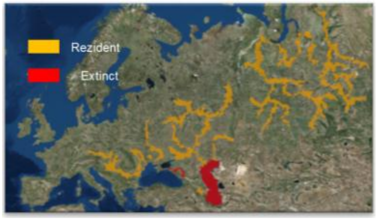


Figure 4.6 The range of populations of Acipenser ruthenus [25]

Huso huso (Linnaeus, 1758) **– Beluga sturgeon**

The Beluga sturgeon (Figure 4.7) is a species found in the basins of the Black Sea, Caspian Sea, Azov Sea and Adriatic Sea (Figure 4.8).

Figure 4.7 Huso huso

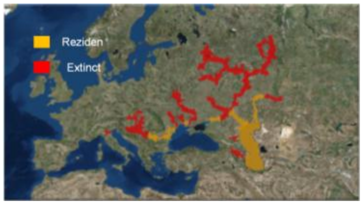


Figure 4.8 The range of populations of Huso huso [26]

Acipenser nudiventris (Lovetsky, 1828) **– Ship sturgeon**

The Bastard (Figure 4.9) is a species found in the basin Black Sea, Caspian Sea, and Azov Sea Adriatic Sea (Figure 4.10).

Figure 4.9 Acipenser nudiventris [27]

Figure 4.10 The range of populations of Acipenser nudiventris [28]

The author during 8 years of research did not identify any specimens of *Acipenser nudiventris* in the Lower Danube area. In the literature, there is only one source that refers to the capture of a specimen of the *Acipenser nudiventris*, during the last 15 years, upstream of

Bratislava. Unlike the other species, the Bastard sturgeon is represented by two types of populations, anadromous and freshwater.

Figures 4.2, 4.4, 4.6, 4.8, 4.10 highlight the areas where sturgeon species are extinct today, compared to their past spreading areas, which underlines the impact of certain pressures caused by the development of society and by the climate change, with a high negative impact on the conservation status of sturgeon species and their habitats.

4.1.1 Capturing of the sturgeons

The analysis of the migratory sturgeons from the Lower Danube was based on the data obtained from the capture of the wild sturgeons, by authorized scientific fishing.

The scientific fishing authorizations, issued by ANPA Bucharest (National Fisheries Agency) for very varied periods, between May 2011 and December 2017, amounted a number of 827 authorized days, of which 684 were productive days.

Due to ANPA limitations has resulted only a theoretical rate of 47% and a realized rate, under the given conditions, of 39%, the situation presented in Table 4.1.

Table 4.1 The number of productive days for the scientific fishing of sturgeon

Year	Months/ days												Authorized days/year	Unproductive days/year	Productive days/year
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII			
2011	-	-	-	-	2	30	15	0	0	24	30	31	132	18	114
2012	0	0	9	4	31	15	0	0	0	8	30	0	97	12	85
2013	0	0	4	30	10	0	0	0	0	24	30	31	129	16	113
2014	0	0	17	30	13	0	0	0	0	0	0	0	60	8	52
2015	0	0	0	10	31	30	31	0	0	19	30	18	169	20	149
2016	0	0	0	0	0	0	0	4	30	31	30	31	126	39	87
2017	0	0	0	0	0	0	22	31	30	31	0	0	114	30	84

Legend

Months without scientific fishing authorized days

Months when scientific fishing was permanently authorized

Therefore, between May 2011 and December 2017, 300 sturgeons of *Huso huso* (beluga sturgeon), *Acipenser stellatus* (stellate sturgeon) and *Acipenser gueldenstaedtii* (Russian sturgeon) were captured.

What should be emphasized is the small number of catches of the species *Acipenser gueldenstaedtii* (Russian sturgeon), in a percentage of only 2% of the total capture.

In choosing the types of tags needed to monitor the specimens, two major aspects were taken into account, namely the hydrodynamic and hydro morphological conditions existing in the Lower Danube and the characteristics of the monitored species (in particular the size of the each sturgeon).

At the same time, the ultrasonic tagging of the sturgeons was identified as the only method, among those identified ones in the state of the art, whereby the sturgeons can be monitored for long periods of time [29] .

Two of the three types of marks used are shown in Figure 4.11.

Figure 4.11 Ultrasonic tags (model V13TP-1x and V16TP-6x)

In Figure 4.12 the entire tagging procedure is presented sequentially, from the moment that the sturgeon is placed into the containment tube and until it is release into the Danube waters.

Figure 4.12 The procedure steps for tagging and releasing the sturgeons

The tagging technique was based on the process called "tonic immobilization", also used in other research projects that have involved ultrasonic tagging of large fish specimens [30]. The immobilization of the sturgeons was necessary to avoid the possible incidents, caused by their movement during the surgical interventions. In order to minimize the stress caused by the abdominal incision, the tissue was anesthetized with xylene. Preoperative and postoperative disinfection was performed with betadine, and to avoid postoperative infections a resistant tissue adhesive was applied, which does not allow water to enter by the intervention area and, at the same time, helping to healing. The suture was performed in all cases with the resorbable surgical cloth.

Prior to the start of the tagging procedure, biometric measurements (total length, standard length, body mass, head diameter, trunk diameter, and tail diameter) were performed for each sturgeon and also the sex was determined with the ultrasound equipment.

4.1.2 Age determination of *Huso huso* sturgeons

The study of the growth parameters, respectively of the body-length-mass ratio is significant for the evaluation of populations and for comparisons regarding the development of the species in different aquatic environments [31]. The length and mass measurements are the starting point in the evaluation of ichthyofauna.

The length-body mass ratio for the catches presented above was determined by the relation (4.1) [32] and shows the growth of the body, represented by units of mass and units of length as a function of the proportionality coefficient (*a*) and allometry (*b*) [33].

(4.1) $W_t = a \cdot L_t^b,$

where:

W_t – total body mass (g);

a – the coefficient of proportionality, constant that indicates the intersection of the regression line;

L_t – total length (cm);

b –coefficient of allometry, indicates the slope corresponding to the growth rate, respectively how the body mass varies depending on the length.

Analysis of population structure by length classes

The frequency distribution of *Huso huso* catches by length classes, for the entire study period, is presented in

Figure *4.13*.

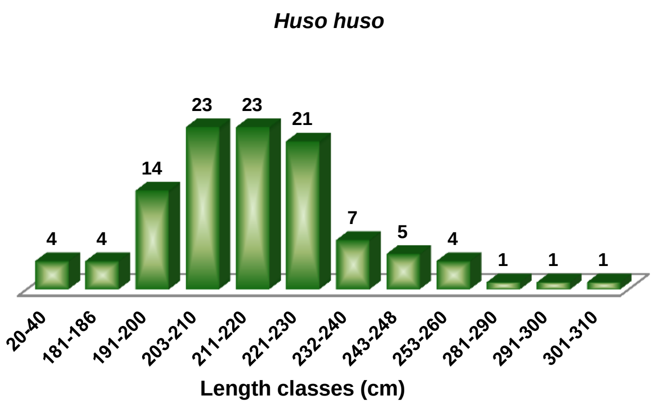


Figure 4.13 Lengths frequency of Huso huso sturgeons captured during the period 2011÷2017

Estimation of weighing calculation errors

Because certain deviations in the measured mass of some *Huso huso* specimens were made by using mechanical scales (Figure 4.14), it was considered necessary to correct the measurement errors.

Figure 4.14 Weighing sturgeons, during 2011÷2017

Therefore, within the thesis, it was developed the coefficient of correction for body masses (CRD) of *Huso huso* specimens, for which weights have been accurately determined after the electronic weighing procedure was subsequently introduced.

Figure 4.15 Weighing specimens, during 2018÷2019

The regression equation for the corrected mass is based on the coefficient (CRD) and is expressed by the relation (4.2), (Deak &Raischi, 2018):

(4.2) $W_t = 2{,}3413 \cdot 10^3 \cdot C_{RD}^{2{,}2421}$,

where:
W_t – total body mass (kg),
C_{RD} – body weight correction coefficient

After the body masses were corrected, the regression equation improved (4.3).

(4.3) $W_t = 7 \cdot 10^{-6} \cdot L_t^{3{,}0137}$.

As a result, the nonlinear regression equation (4.3), obtained for the sample with 108 sturgeons, was used to determine the proportionality coefficient *a* = 0.007 and the coefficient of allometry *b* = 3.013691. Therefore, in the case of the Beluga specimens analysed, a positive allometry (*b*> 3) was found, whereby the growth is achieved more in body mass, than in length [34]. Finally the growth equations were determined according to the total length (4.4) and the body mass of the *Huso huso* sturgeons (4.5):

(4.4) $L = 18{,}843 \cdot t^{0{,}8441}$

(4.5) $W = 0{,}063 \cdot t^{2{,}4615}$.

By integrating on the same graph the equations described above, it was possible to obtain the age according to the length and body mass for the 108 specimens of *Huso huso* analysed Figure 4.16.

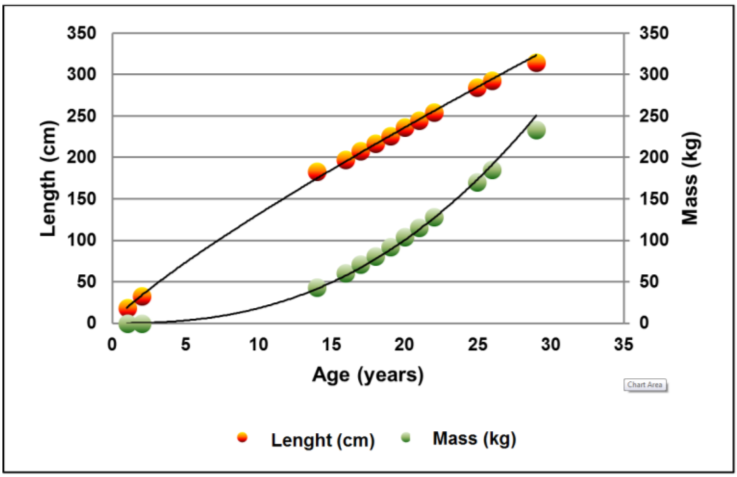


Figure 4.16 Growth analysis of Huso huso sturgeons from the Lower Danube (Raischi&Deak, 2018)

According to the growth equations in length and body mass, the age of the mature specimens analysed varies between 14 ÷ 29 years. According to most authors [6] [35], the maturity in the case of the species *Huso huso* (beluga) is evident around the age of 10÷16 years. By correlating the data from the literature with the interpretations presented above, it turns out that 78% of the evaluated sturgeons were at the first or second spawning time.

Assessment of the conservation status of *Huso huso* population in the Lower Danube

For the entire research period 2011 ÷ 2017, the numerical number of 104 adult and 4 juveniles (captured and released), was classified into twelve classes of lengths ranging from 20 to 310 cm. The highest frequencies in catches were recorded in the length classes between 191 and 230 cm (77.89%).

By interpreting the results, regarding the number of specimens and their age in the sample, the following distribution was observed:

- - 4% - juvenile specimens,
- - 78% - specimens at first and second spawning time,
- - 15% - specimens at the third spawning time,
- - 3% - specimens at the fourth or fifth spawning time.

4.1.3 Age determination of *Acipenser stellatus* sturgeons

Analysis of population structure by length classes

The distribution of the catch frequencies by length classes, for the entire study period, is shown in Figure 4.17.

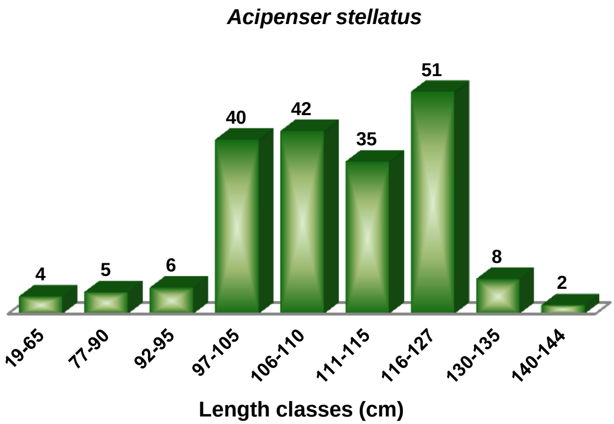


Figure 4.17 Lengths frequency of Acipenser stellatus sturgeons captured during the period 2011÷2017

In the case of Stellate sturgeons, the variation of the length depending on the body mass is represented by equation (4.6):

(4.6) $Wt = 8{,}612942 \cdot 10^{-6} \cdot Lt^{2{,}811932}$.

Subsequently, the proportionality coefficient *a* = 0.0086 and the coefficient of allometry *b* = 2.8119 were determined. Furthermore, for the captured specimens, a negative allometry was identified (*b* <3), specifying the increase in length rather than in body mass.

Finally, the growth equations were determined based on the total length (4.7) and body mass of the specimens. (4.8):

(4.7) $L = 46{,}27 \cdot t^{0{,}3984}$

(4.8) $\mathrm{W} = 0{,}3505 \cdot \mathrm{t}^{1{,}1733}$.

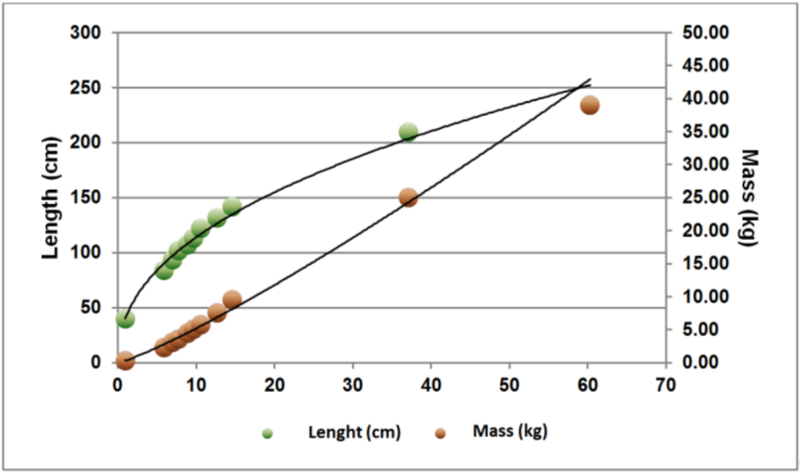


Figure 4.18 Growth analysis of Acipenser stellatus sturgeons from the Lower Danube (Raischi&Deak, 2018)

According to the graphs presented, at the time of capture and release, most of the Stellate sturgeons were at the age of 7-11 years at the second spawning time.

Assessment of the conservation status of the *Acipenser stellatus* population in the Lower Danube

The number of Stellate catches, during the entire study period, was 189 adult and 4 juvenile, represented by nine classes of lengths ranging from 19 to 144 cm. The highest frequencies in catches were recorded in the length classes from 97 to 127 cm (88.9%).

Correlating the data from the specialized literature, according to which the specimens of Stellate are spawning every 2 to 3 years, with the determined age of the specimens, it can be concluded that, in the evaluated sample, the specimens were: 2% juveniles with the age of 1 ÷ 2 years, 64% at the first or second spawning, 27% at the third spawning and only 5% at the fourth or fifth spawning time.

By interpreting the results, regarding the number of sturgeons and their age in the sample, the following distribution was observed:

- 2% - juvenile sturgeons,
- 66% - sturgeons at the first or second spawning,
- 27% - sturgeons at the third spawning,
- 5% - sturgeons at the fourth or fifth spawning.

CHAPTER V MONITORING STURGEON HABITATS AND MIGRATION IN THE LOWER DANUBE

5.1 Analysis of water quality indicators and sediment in the Bala branch area

The Danube is of great economic and strategic importance due to the maritime and river transport. The river is also important from the tourist point of view for all of the 10 countries it crosses (Germany, Austria, Slovakia, Hungary, Croatia, Serbia, Bulgaria, Romania, Ukraine, Republic of Moldova) and for the all four capitals (Vienna, Bratislava, Budapest, Belgrade) Figure 5.1. [37]

Figure 5.1 Danube course [38]

5.1.1 Water quality analysis

In Romania, the quality of surface waters is evaluated by Norm 161/2006, which refers to the ecological and chemical classification of all categories of surface waters [38]. This norm was issued based on the provisions of the Water Law no. 107/1996 with the subsequent modifications and completions of articles 3 and 10, approved by the Government Decision no. 351/2005 regarding the approval.

To analyse the water quality, taking into account the law provisions and the , 4 sampling sections were established (Figure 5.2), which have assured control over the investigation area, for each of them has been collecting samples from the left, right and centre areas, from depths of 0.5 m, 1, 5 m and 3 m.

Figure 5.2 Location of water sampling and sediment sampling points

The sampling sections were chosen in order to analyse the influence over time of the hydro technical works on the quality of the water and sediments, therefore ensuring a high confidence level monitoring. The oxygen regime was analysed, knowing that the Bala branch has potential for being a habitat area for the sturgeon species. Also, water and sediment samples were analysed from the point of view of metals, considering that sturgeons, as part of the aquatic ecosystem, are exposed to bioaccumulation with heavy metals.

5.2 Monitoring of sturgeon migration from the Lower Danube

To identify the migration routes of anadromous ultrasonic-tagged sturgeons, mobile and fixed monitoring stations were placed on a section of the Danube with over 600 km in length (Figure 5.3).

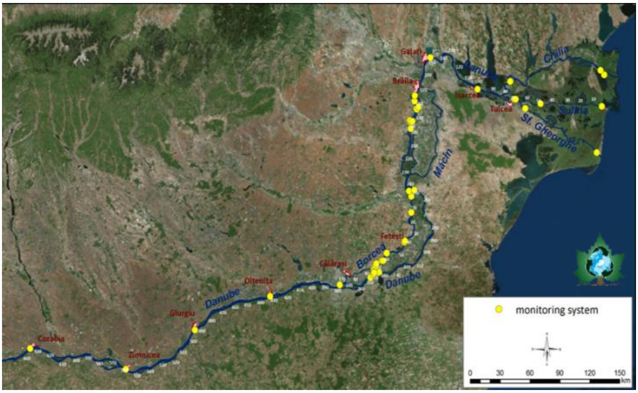


Figure 5.3 Localization of monitoring systems on the Danube (2016)

Depending on the morphology of the section, in some locations, only one station was used, and in others, several stations were used to ensure the reception of the ultrasonic signal throughout the entire transversal section.

Furthermore, to ensure the reception area over the entire area of interest Bala Branch – bottom sill, where there are swirl areas that disturb the reception signal, the stations were positioned at distances from 50 to 50 m in length on both banks. Figure 5.4 shows the positioning of the stations in the investigation area on the Bala branch.

Figure 5.4 Location of monitoring stations on the Bala branch area

The choice of the location was made after a hydrodynamic and hydro morphological evaluation of the transversal and longitudinal sections, respectively of the water flow, flow dynamics, the morphology of the riverbed and the water level.

Water flow and velocity were determined using ADCP bathymetric equipment: River Ray and River Surveyer. In order to know the hydrological parameters in the location of the monitoring systems, measurements were initially made in longitudinal and cross sections with ADCP equipment (Figure 5.5), which allowed the identification of the most suitable areas for the location of the monitoring stations (Figure 5.6).

Figure 5.5 Single beam measurement of the riverbed in the location of the monitoring stations

To analyse parameters like the depth and water temperature in time of sturgeon movement it was necessary to identify a solution to reduce the effects of the turbidity and swirls which made the signal reception to not be intercepted by the monitoring stations. For minimise those kind of issues, the author together with the INCDPM experts, after carrying out numerous in situ experiments on determining the reception distance of the monitoring stations, have developed a technical solution called gate-type stations, which consists of positioning monitoring stations in mirror-like positions, on the left and right bank, therefore covering the entire width of the river.

Downloading the volume of data stored in the receivers (Figure 5.7) was done directly on the computer, using the VUE program (VEMCO User Environment software).

Figure 5.6 Mobile/floating monitoring station located on the Danube

Figure 5.7 Downloading sturgeon migration data

5.3 Characterization of sturgeon behaviour in the monitored sector

To identify the migration and behaviour of ultrasonic-tagged sturgeons, both mobile/floating and fixed stations, located in well-established locations, as well as the equipment for detecting VR 100 ultrasonic signals (Figure 5.8) were necessary to locate the specimens during the periods where they were outside of the reception areas of the monitoring stations.

Figure 5.8 Monitoring the behaviour of sturgeons (downstream of the Bala branch)

The behaviour of ultrasonic-tagged sturgeons was monitored from the moment the presence of a sturgeon returning from the Black Sea has been identified and confirmed at the alarm station located at the INCDPM - Feteşti Work Point or from the moment of its release after the tagging operation.

5.3.1 Migration and behaviour of Beluga sturgeons

The results obtained from the monitoring of the behaviour of 4 ultrasonic-tagged sturgeons of the *Huso huso* species will be presented below.

The first sturgeon of *Huso huso* **species, identification code M1,** was captured, tagged and released at km 43, Borcea's branch on November 9, 2011. The captured specimen was a male, with a total length of 205 cm and body weight of 65 kg. Table 5.1 presents the data recorded for the migration of M1 specimen.

Table 5.1 Migration Data of M1 Beluga sturgeon

Date	Area	Detection period	Average temperature (^{0}C)	Depth (m)		
				Minimum	Average	Maximum
10.11.2011 (23:24:50 ÷ 23:40:18)	Borcea Km 42	16 minutes	10	6,82	8,38	9,24
14.11.2011 (09:37:35 ÷ 11:05:44)	Dunare Km 187	1 hour și 29 minutes	8	4,24	11,11	16,82
17.11.2011 (20:01:30 ÷ 23:25:24)	Dunare km 100	3 ore și 25 minutes	8	3,79	7,77	10,16
30.12.2015 (11:33:03 ÷ 11:45:53)	Chilia aval.	13 minutes	5	6,22	10,79	13,34
01.01.2016 (09:53:12 ÷ 10:11:35)	Chilia amonte.	18 minutes	5	13,19	16,09	18,65
03.01.2016 (19:41:48) ÷ 24.01.2016 (09:13:56)	Dunare mila 80	21 days and 4 hours	2	8,79	13,93	18,80
30.01.2016 (07:21:48) ÷ 02.02.2016 (10:49:32)	Borcea km 0	3 days si 4 hours	3	14,40	17,80	19,10
04.02.2016 (07:21:42) ÷ 13.03.2016 (08:56:54)	Bala – downstream bottom sill	aprox. 38 days	6	6,39	17,05	28,35
13.03.2016 (11:54:16 ÷ 11:57:17)	Dunare km 348	3 minutes	8	15,61	15,76	15,91
23.03.2016 (15:45:26 ÷ 15:48:49)	Dunare Km 633	3 minutes	9	9,55	9,55	9,55
09.05.2016 (05:22:24 ÷ 05:52:21)	Dunare km 348	30 minutes	16	5,3	6,33	8,18
09.05.2016 (06:28:15 ÷ 06:50:00)	Dunare km 343	22 minutes	16	5,76	6,64	7,12
10.05.2016 (08:49:57 ÷ 09:01:33)	Dunare km 252	11 minutes	16	8,03	9,18	10,16
11.05.2016 (01:46:48 ÷ 01:50:11)	Dunare km 195	3 minutes	16	5,31	5,31	5,31
11.05.2016 (04:28:21 ÷ 04:39:15)	Cravia	12 minutes	16	4,09	5,46	6,21
11.05.2016 (13:02:46)	Dunare mile 80		16			
12.05.2016 (01:39:52 ÷ 01:55:27)	Dunare mile100	16 minutes	16	6,37	7,23	8,34
12.05.2016 (11:00:28 ÷11:15:43)	Chilia upstream	16 minutes	16	8,64	10,73	12,43
13.05.2016 (11:36:29 ÷11:40:27)	Chilia downstream	4 minutes	17	4,69	5,16	5,76

The general behaviour of the M1 Beluga specimen indicates that on February 4, 2019, it was detected in the area below the bottom sill, after which it moves downstream in the same day, and stays at km 7 of the Bala branch until February 8, 2016. M1 continue the downstream movement until February 9, 2016, in the Unirea area. Then on February 13, 2016, it returned to km 3 of the Bala branch. On February 17, 2016, it swam downstream from the bottom sill, after which on March 4, 2016, it moves to km 8 of Bala's branch, where it is supposed to have stayed for 4 days, finally it swim upstream to the bottom sill and manage to overcome it on March 13, 2016.

On March 13, 2016, M1 swam over the bottom sill area, the last detection in its upstream movement being recorded at km 633 of the Danube (Table 5.1).

The author performed a complex decision analysis, based on the (unique) data provided by the monitoring stations located in the bottom sills area on the Bala branch, in conjunction with the (unique) data obtained in real-time monitoring with the VR100 device, regarding the M1 Beluga behaviour under the conditions of existence of the two submerged obstacles, namely the Old Bottom Sill (OBS) and the New Bottom Sill (NBS).

The result of the decision analysis reflects the following behaviour of the M1 Beluga specimen influenced by OBS and NBS:

- M1 arrive in the detection range of the stations located in the OBS and NBS areas, on February 4, 2016, at 07:21 a.m. near the right bank of the Bala branch and for 5:37 hours it oscillates between the two banks, after which it swims upstream near the right bank downstream of OBS (for 8 minutes), cross to the left bank downstream of OBS (for 23 minutes), then returns to the right bank also downstream of OBS (for18 minutes) and descend into the area then enters in the stations detection range. Has to be specified that M1 crossed the Bala branch 2 times, from one bank to the other downstream of the OBS, indicating that the submerged obstacle caused it to return, **it has not found a way to cross it;**

- M1 sturgeon returns on February 4, 2016, at 5:10 pm, after leaving the area for approximatively 3 hours and continues to oscillate between the banks, respectively in the detection area located downstream of bottom sills, without going up. At that time, M1 was detected in real-time in the area of km 7 of the Bala branch;
- on February 5, 2016, M1 oscillates at the entrance of the detection area, between the banks, between time interval 01:24 ÷ 03:01. It passes over the OBS near the left bank and arrives downstream of the NBS. It is noteworthy that the first attempt to cross the NBS took place after which M1 has descends and left the detection area for about 1 day. M1 has been detected in real-time at km 7 on the Bala branch, from where it returned on February 6, 2016, at 06:36, near the right bank;
- on February 6, 2016, M1 oscillates between the banks and leaves the bottom sills area for approximately 11 hours, being detected in real-time at km 7 of the Bala branch, from where it returns to the right bank between 8:18 pm. and 8:39 pm. and moves downstream from OBS in 17 minutes. It passes to the left bank, downstream of the OBS in 29 minutes and returns to the entrance of detection area on the right bank, after which it leaves the area for 1 day. It is noted that this time M1 did not find the way to cross the submerged obstacle of OBS, although it had been able to overcome it the day before;
- M1 returns on 08.02.2016, at 03:23, in the detection area of bottom sills near the right bank, moves downstream of the OBS in 29 minutes and crosses to the left bank along the OBS, downstream of it, descend to the entrance area on the Bala branch where it oscillates between the banks approximately for 3 hours, after which it leaves the detection area, being detected in real-time at km 7 of the Bala branch. From that moment, for 4 days and 6 hours (respectively from February 8, 2016, until February 12, 2016, 4 pm.) it is not detected by any stations that monitor the OBS and NBS areas. During this time, M1 was detected in real-time at the Unirea area, on February 9, 2016. From that moment until February 12, 2016, when it returned to the detection area of bottom sills located on the Bala branch. There was an acceptable probability that, while M1 descends or oscillates between the banks, in search of a suitable spawning area, it probably has encountered a female and returned to the detection area on 12.02.2016. **It is worth noting that the M1 tried to cross the submerged obstacle of OBS and left the area without success;**
- on February 12, 2016, at 4:07 pm, M1 returns to the detection area near the right bank, oscillates between the banks and leaves the detection area several times, then returns to the right bank and swims diagonally, passing from OBS and reaching the right bank downstream from NBS on the same day at 23:42, where it remains approx. 2 hours and a half, until February 13, 2016, 2:11 am. From there descend to the entrance of the detection area and oscillate between the banks, then leave/return to the monitoring area. M1 was detected in real-time at km 3 of the Bala branch on February 13, 2016. **It is noted that M1 had a second attempt to overcome the submerged obstacle NBS, after managed to surpassed OBS for the second time; on February 14, 2016,** M1 returns near the right bank at 00:54 and oscillates between the banks until 02:48 am.,

then leaves the monitoring area approx. 1 day and 8 hours. M1 returns to the detection area near the right bank on February 15, 2016, 10:44 am and, after oscillations between the banks, leaves the monitoring area at 5:55 pm. Detections are missing for 15 days and 9 hours, until March 2, 2016, 3:07 am, when it returns to the detection area, having the same behaviour to that analysed in the days of February 14 and 15, 2016. M1 leaves the detection area on February 15, 2016, at 22:16, for 6 days and 2 hours. In the time interval between March 4 and 8, 2016, M1 was detected in real-time at km 8 of the Bala branch;

- on March 9, 2016, at 2:19, M1 is present in the detection area from the right bank and swims upstream for 31 minutes, downstream of the OBS. It is noted that M1 oscillates along the OBS, downstream, between the right bank and the left bank of the Bala branch, and then swims upstream near the left bank towards the NBS, crossing the OBS. At the same time, it is noted that the M1 crossed the Bala branch 3 times, downstream of the OBS, for 36 minutes, after which the first attempt to pass the NBS took place, approx. 1 hour, in March 2016. After the unsuccessful attempt to cross the NBS, M1 moves downstream on the left bank, leaves the detection area for a period of 1 day and 16 hours. M1 returns on March 10, 2016, at 22:40, with an oscillating behaviour, leaving the detection area and returning to the right bank, remaining between the bottom sills until March 12, 2016;
- on March 13, 2016, the M1 sturgeon returns to the right bank at 03:27. After 5 minutes it swims up the right bank downstream of the OBS and crosses the Bala branch towards the left bank, along the OBS, down the bottom sill, all that for approx. 32 minutes. After which it passes the OBS in about 55 minutes and reaches downstream of NBS. After 2 minutes, M1 starts the crossing of the NBS, which takes 2 hours and 16 minutes, passing from the left bank on the right bank. A subsequent registration locates the presence of M1 at Izvoarele, at noon, after approx. 3 hours. **It is important to note that M1 passes OBS in 55 minutes on the left bank and then passes NBS in 2 hours and 16 minutes; practically, the overcoming of the OBS and NBS submerged obstacles lasted approx. 3 hours.**

The second specimen of Huso huso , identification code M2 was captured on November 3, 2011 and released the same day in the area of Borcea branch at km 43, having a total length of 210 cm and a body mass of 70 kg.

In 2012, there were no type 1 monitoring stations (used together with INCDPM - INCDD Subunit Tulcea) located in the proximity of the bottom sills (Bala branch). The stations being located in the Izvoarele area and have been lost, due to their inefficiency in the harsh hydrological conditions and specific hydrodynamics of the Danube River. Therefore there is no data available for analysis of its movement behaviour of M2 on the Bala branch in the mentioned year.

Table 5.2 Migration Data of M2 Beluga sturgeon

Date	Area	Detection Period	Average Temperature (^{0}C)	Depth (m)		
				Minimum	Average	Maximum
05.11.2011(03:39:36) ÷ 29.04.2012 (16:45:36)	Bala km. 7	176 days (detections at 05.11.2011 and 29.04.2012)	14	3,34	9,13	19,10
29.04.2012 (18:59:13 ÷ 19:00:03)	Borcea km. 64	1 minutes	16		10,31	
30.04.2012 (22:41:10 ÷ 22:50:37)	Dunare km. 187	9 minutes	16	8,19	9,52	11,22
30.04.2012 ÷ 01.05.2012	Dunare km. 180	14 minutes	16	5,91	6,95	8,19
01.05.2012 (16:55:14 -17:36:37)	Dunare km. 100	41 minutes	17	5,46	7,05	9,55
11.02.2016 (11:06:54 ÷ 11:18:54)	Chilia downstream	12 minutes	4	9,10	12,05	13,80
14.02.2016 (13:13:57 ÷ 13:28:31)	Chilia upstream	14 minutes	5	10,46	14,81	16,52
16.02.2016 (07:05:13 ÷ 08:16:46)	Dunare km. 100	71 minutes	5	11,07	13,66	16,37
18.02.2016 (12:00:15 ÷ 12:03:23)	Dunare mile 80	3 minutes	7		13,80	
21.02.2016 (01:51:36 ÷ 02:10:24)	Cravia	19 minutes	6	4,24	8,71	12,43
22.02.2016 (01:57:01 ÷ 02:36:36)	Dunare km. 195	39 minutes	6	6,22	8,16	9,10
22.02.2016 (10:05:20 ÷ 10:56:14)	Dunare km. 200	51 minutes	6	7,43	11,17	15,77
27.02.2016 (21:47:38 ÷ 22:25:28)	Borcea km. 0	38 minutes	8	7,28	13,08	17,59
9 days it has stayed between Borcea branch km. 0 and Borcea branch km. 43						
08.03.2016 (07:06:27 ÷ 07:08:47)	Borcea km. 43	2 minutes	8	15,16	15,16	15,16
09.03.2016 (14:00:11) ÷- 10.03.2016 (08:15:30)	Bala branch-downstream bottom sill	18 hours	9	3,18	8,76	25,62
10.03.2016 (10:47:55 ÷ 10:54:04)	Dunare km. 348	6 minutes	9		16,37	
11.03.2016 (04:00:40 ÷ 04:02:56)	Dunare km. 375	3 minutes	9		9,55	

It is obvious that the M1 and M2 Beluga specimens have different general behaviours, although they have close physical characteristics (length, mass, sex, age) and that these were captured, tagged and released in the same month. The only behavioural similarities are that they swam against water currents at great depths and returned for the spawning cycle in approx. 4 years, characteristics that may be generally valid for this species. The behavioural differences between the two specimens are:

- M1, after its release, slowly moved downstream back to the Black Sea and returned to the Danube for spawning in December, migrating also at temperatures of 2 ÷ 3 ^{0}C vs. M2 which, after its release, moved upstream for spawning and swam rapidly downstream to the Black Sea, returning for spawning in February, migrating at temperatures of 4 ÷ 5 ^{0}C;
- M1 arrived in the area of the new bottom sill on February 4 and had an oscillating behaviour, crossing the hydro technical construction on March 13, vs. M2 that reached the new bottom sill area on March 9 and had a non-oscillating behaviour, crossing the hydro technical construction on March 10;
- Specimen M1 crossed the new bottom sill in the morning, between 5:36 ÷ 7:52 (for 136 minutes), from the left bank area reaching the right bank area (after NBS, in the funnel erosion zone) vs. specimen M2 that crossed the NBS also in the morning, but between the hours of 7:49 ÷ 8:15 (for 26 minutes), at depths of 15 m (possibly in the area of the

left bank, in the scour pit before NBS) and 11 m (after NBS in the funnel effect erosion area near the left bank);

- M1, after it reproduced beyond km 633 of the Danube, migrated to the Black Sea via the Old Danube vs. M2 which was poached at km 375 of the Danube.

The third specimen, identification code M3 was captured on November 15, 2015, tagged and released the same day in the area of Borcea branch at km 43, having a total length of 210 cm and body mass of 80 kg.

Table 5.3 Migration Data of M3 Beluga sturgeon

Date	Area	Detection period	Average temperature (°C)	Depth (m)		
				Minimum	Average	Maximum
15.11.2015 (12:37:30) ÷ 16.11.2016 (14:11:08)	Borcea km. 43	26 hours	12	1,06	10,40	14,10
17.11.2015 (20:48:02 ÷ 21:25:10)	Borcea km. 0	37 minutes	12	4,09	8,83	11,61
18.11.2015 (18:33:40 ÷ 19:43:26)	Dunare km. 200	1 hour and 10 minutes	12	3,64	8,90	11,61
18.11.2015 (21:04:48 ÷ 21:09:17)	Caleia km.10	5 minutes	12	5,00	7,41	11,61
18.11.2015 (21:17:46 ÷ 21:34:40)	Caleia km. 9	17 minutes	12	1,36	7,64	11,61
03.04.2016 (04:51:57 ÷ 05:06:37)	Chilia upstream	14 minutes		10,51	15,39	23,95
04.04.2016 (06:09:35 ÷ 06:36:30)	Dunare km. 100	27 minutes		9,10	11,04	13,04
05.04.2016 (17:56:29 ÷ 17:59:17)	Dunare mile 80	3 minutes		11,61	14,81	17,74
06.04.2016 (18:59:00 ÷ 19:27:55)	Dunare km. 182	29 minutes		10,16	13,03	15,01
07.04.2016 (01:58:16 ÷ 02:04:22)	Dunare km. 195	6 minutes		8,34	10,87	12,55
07.04.2016 (04:19:33 ÷ 04:31:32)	Dunare km. 200	12 minutes		4,40	8,14	12,40
08.04.2016 (10:41:21 ÷ 11:34:15)	Borcea km. 0	54 minutes		8,64	13,85	20,47
19.04.2016 (16:43:21 ÷ 17:11:26)	Borcea km. 43	28 minutes		8,94	13,33	16,63
26.04.2016 (10:18:14 ÷ 14:50:15)	Bala-downstream bottom sill	4 hours and 32 minutes		2,58	14,43	21,07
26.04.2016 (15:49:27 ÷ 16:22:05)	Dunare km. 348	33 minutes		7,88	12,11	15,85
27.04.2016 (03:06:25 ÷ 03:11:20)	Calarasi km. 375	5 minutes		8,94	12,07	15,53
19.05.2016 (23:49:40) ÷ 20.05.2016 (00:19:20)	Dunare km. 348	30 minutes		1,82	10,63	17,10
20.05.2016 (00:41:17 ÷ 01:04:07)	Bala-upstream bottom sill	23 minutes		1,21	7,81	17,10
20.05.2016 (19:00:14) ÷ 22.05.2016 (22:45:59)	Borcea km. 43	28 hours		3,49	12,52	18,20
23.05.2016 (10:37:07 ÷ 10:59:27)	Borcea km. 0	22 minutes		6,97	13,10	18,04
23.05.2016 (23:11:13 ÷ 23:20:24)	Dunare km. 200	9 minutes		4,70	11,28	18,51
24.05.2016 (01:07:21 ÷ 01:50:58)	Caleia km. 9	44 minutes		3,03	10,37	18,51
24.05.2016 (03:04:38 ÷ 22:32:00)	Dunare km.182	19 hours		3,34	12,13	18,67
25.05.2016 (07:57:43 ÷ 08:17:28)	Chilia upstream	19 minutes		5,46	12,06	18,67

As of May 19, 2016, M3 migrates to the Black Sea via the Bala branch, passing through the NBS area in 23 minutes at shallow depths, than to Borcea branch, the Old Danube and lastly the Chilia branch. It is important to note that the upstream movement on April 3, 2016 and downstream movement on May 25, 2016, of the M3 specimen were detected on the Bâstroe canal, only by the monitoring station positioned upstream. In the context that, in Strasbourg, within the Standing Committee of the Bern Convention (2016), the representative of Ukraine has given assurances that there will not be any more dredging operations on the Bâstroe canal, corroborated with the fact that the monitoring station located downstream has no detections from M3, it concludes that the specimen migrated downstream mainly on this channel and not on the branch of Stambulul Vechi.

The fourth specimen, identification code M4 was captured on November 18, 2015, tagged and released the same day in the area of Borcea branch at km 43, with a total length of 220 cm and a body mass of 90 kg.

Table 5.4 Migration Data of M4 Beluga sturgeon

Date	Area	Detection period	Average temperature (ºC)	Depth (m)		
				Minimum	Average	Maximum
18.11.2015 (16:08:29) ÷ 19.11.2015 (17:17:43)	Borcea km. 43	25 hours and 9 minutes	11	1,67	11	15,31
20.11.2015 (22:48:23 ÷ 23:32:07)	Borcea km. 0	44 minutes	11	4,55	11	15,01
22.11.2015 (22:14:37 ÷ 23:26:43)	Dunare km. 200	73 minutes	12	7,43	10	12,28
23.11.2015 (0:34:47 ÷ 0:43:27)	Caleia km. 10	9 minutes	12	4,70	8	11,47
23.11.2015 (0:53:30 ÷1:06:53)	Caleia km. 9	14 minutes		7,13	10	11,47
04.04.2016 (1:22:52 ÷1:34:54)	Sulina downstream	12 minutes		6,06	10	13,49
06.04.2016 (2:04:18 ÷ 2:12:22)	Sulina upstream	8 minutes		11,63	14	19,86
07.04.2016 (2:15:45) ÷ 08.04.2016 (2:39:46)	Tulcea	24 hours and 24 minutes		8,34	16	31,99
08.04.2016 (18:56:55 ÷ 19:30:21)	Dunare km. 100	34 minutes		10,16	12	13,04
12.04.2016 (10:16:3 ÷ 10:20:21)	Dunăre mila 80	4 minutes		13,83	16	17,59
13.04.2016 (4:54:38 ÷ 5:22:13)	Dunare km. 182	28 minutes		11,82	15	16,98
13.04.2016 (12:42:37 ÷ 12:58:29)	Dunare km. 195	16 minutes		9,70	12	14,46
13.04.2016(15:00:56 ÷ 15:35:07)	Dunare km. 200	35 minutes		8,79	14	18,50
14.04.2016 (19:32:2 ÷ 20:14:54)	Borcea km. 0	42 minutes	15	13,34	16	20,62
20.04.2016 (13:48:29 ÷ 13:55:40)	t Borcea km 43	7 minutes	17	11,52	14	16,65
23.04.2016 (3:08:59 ÷ 6:21:02)	Bala-downstream bottom sill	3 hours and 13 minutes	16	9,39	17	24,26
23.04.2016 (7:41:03 ÷ 8:37:09)	Dunare km 348	56 minutes	16	7,88	14,00	16,34
23.04.2016 (21:02:26 ÷ 21:08:41)	Dunare km 375	6 minutes	17	9,70	14,12	16,81
29.04.2016 (11:31:30 ÷ 11:40:56)	Dunare km. 633	9 minutes		6,52	10,98	16,02
05.06.2016 (23:20:42 ÷ 23:30:36)	Dunare km. 375	10 minutes		12,28	17,36	22,14
06.06.2016 (21:51:16 ÷ 22:35:21)	Dunare km. 348	44 minutes		3,94	16,10	22,14
06.06.2016 (23:09:45 ÷ 23:38:08)	Braț Bala-upstream bottom sill	29 minutes		9,10	13,58	21,99
07.06.2016(23:47:41 ÷ 23:55:57)	Borcea km. 43	8 minutes		11,07	17,55	21,83
08.06.2016 (18:44:22 ÷ 19:08:18)	Borcea km. 0	24 minutes		11,37	18,43	22,14
09.06.2016 (14:57:11 ÷ 20:36:00)	Caleia km. 10	5 hours and 39 minutes		6,97	15,22	22,14
09.06.2016 (20:49:36 ÷ 21:11:19)	Caleia km 9	22 minutes		8,79	16,28	21,99
09.06.2016 (23:11:12 ÷ 23:23:56)	Dunare km. 182	12 minutes		7,43	15,46	21,99
10.06.2016 (8:13:25)	Dunăre mila 80				9,85	
11.06.2016 (14:27:34 ÷ 14:39:52)	Chilia upstream	12 minutes		11,52	18,21	21,83
12.06.2016 (17:50:48 ÷ 17:57:54)	Chilia downstream	7 minutes		7,58	13,83	22,14

From the information volume obtained from the fixed and floating monitoring stations located on the Bala branch, near the bottom sills, it results that the M4 specimen arrived in the detection area on April 23, 2016, crossed the NBS in 3:13 hours, passed the detection areas from Izvoarele stations and km 375 in the same day, arriving on April 29, 2016 at km 633 where, it has a single time interval, it can be considered with a high level of confidence that it has reproduced downstream, within 37 days, when new detections are registered at the station at km 375, on June 5, 2016. On June 6, 2016, M4 reaches Izvoarele and, on the same day, crosses downstream the bottom sill, in 29 minutes. On June 11, 2016, it arrives in the monitoring area of the Bâstroe Canal, at the upstream station and leaves the detection area of the downstream station on June 12, 2016, migrating to the Black Sea on the Stambulul Vechi branch.

In conclusion, it is obvious that the specimen of *Huso huso*, M3 and M4 have a less different behaviour during the return period to the Black Sea, in the sense that after being released in the same month, they move rapidly downstream on the Caleia branch and after returning to the Danube for the reproduction cycle, approx. 5 months, they pass in the same day, when they arrived in the bottom sill monitoring area, over the NBS and after breeding they return to the Bala branch. The differences are more obvious, because the M3 swims upstream on the Bâstroe channel via the Chilia branch, and the M4 swims upstream on the Sulina branch via the Tulcea branch, and M3 moves downstream on the Chilia branch and the Bâstroe channel, and M4 on the Chilia branch - the Stambulul Vechi channel route. The breeding period for the M3 specimen is shorter than of M4, because it starts at the end of April for M3 at km 375 of the Danube, and for the other one at km 633.

5.3.2 Migration and behaviour of the Stellate sturgeons

The specimen of the *Acipenser stellatus* species – Stellate sturgeon with identification code P3, was captured, tagged and released at km 7 of the Borcea branch, in June 2012. The specimen was male, with a total length at that time of capture of 119 cm and a body mass of 5 kg.

Table 5.5 Migration data of P3 Stellate sturgeon

Date	Area	Detection period	Average temperature (°C)	Depth (m)		
				Minimum	Average	Maximum
23.06.2012 (23:03:10 ÷ 23:14:36	Caleia km. 9,2	11 minutes	27	1,36	3,79	8,49
24.04.2014 (15:37:24 ÷ 16:09:41)	Chilia downstream	32 minutes	15	5,61	8,72	10,76
24.04.2014 (16:48:44 ÷ 17:12:08)	Chilia upstream	24 minutes	16	5,61	9,58	11,98
02.05.2014 (20:46:37 ÷ 20.50.56)	Dunare km. 186	4 minutes	16	9,25	13,64	17,28
03.05.2014 (03:40:59 ÷ 04.04.40)	Dunare km. 195	24 minutes	16	5,76	7,46	8,79
03.05.2014 (07:37:27 ÷ 08.01.49)	Dunare km. 200	25 minutes	16	13,49	14,7	15,6
05.05.2014 (05:12:19 ÷ 05.26.59)	Borcea km. 3,5	1 hour and 14 minutes	16	18,19	19,07	20,16

In accordance with the data presented in Table 5.5, P3 specimen returned to the Danube after about 2 years, the first detection being recorded on the Chilia branch. The last detection of the P3 specimen was on May 5, 2014, in the area of the Borcea branch at km 3.5, after which it was no longer detected by any monitoring station, it certainly has been poached.

The specimen of the species *Acipenser stellatus* – Stellate sturgeon with identification code P5 was captured, tagged and released on the Borcea branch at km 20, in May 2013. The specimen was male with a total length at the time of capture of 120 cm and body mass. 5.5 kg.

Table 5.6 Migration data of P5 Stellate sturgeon

Date	Area	Detection period	Average temperature (°C)	Depth(m)		
				Minimum	Average	Maximum
17.05.2013 (21:25:30 ÷21:39:32)	Borcea km 3,5	1 hour and 14 minutes	20	0,30	5,83	14,40
12.05.2013 (06:12:20 ÷ 06:23:02)	Isaccea km. 100	11 minutes	22	8,64	10,01	12,13
28.04.2016 (03:27:20 ÷ 03:33:36)	Chilia upstream Bâstroe	6 minutes	16	10,16	11,87	12,73
01.05.2016 (04:29:08 ÷ 04:47:26)	Chilia upstream Ceatalchioi	18 minutes	17	13,19	15,43	17,43
04.05.2016 (05:47:21 -06:03:49)	Galati (Dunare mile 80)	17 minutes	17	21,53	21,95	22,59
05.05.2016 (14:20:09 ÷14:48:22)	Dunare km. 182	28 minutes	16	14,40	15,61	16,22
06.05.2016 (04:53:09 ÷ 05:15:02)	Dunare km. 200	22 minutes	15	15,31	17,46	19,86
08.05.2016 (10:33:13 ÷11:35:01)	Borcea km. 0	1 hour and 2 minutes	16	11,37	19,60	24,41

In accordance with the data presented in Table 5.6, specimen P5 returned to the Danube after about 3 years, moving upstream on the Chilia branch (similar behaviour to specimen P3). Another similarity with P3 is the longer stay on Borcea branch and the fact that it was poached in the same area.

5.4 Migration of sturgeons on the Bala branch under different hydrological conditions

During the *in situ* investigations and monitoring of sturgeons, in several campaigns, numerous 2D and 3D bathymetric measurements were made.

Figure 5.9 shows the morphology of the new bottom sill (NBS), which was constructed in a proportion of 90% in 2016, and that of the old bottom sill (OBS), built in the 1990s with the same purpose to improve the navigation conditions and which is located at a distance of approx. 600 m from the Bala – Old Danube confluence.

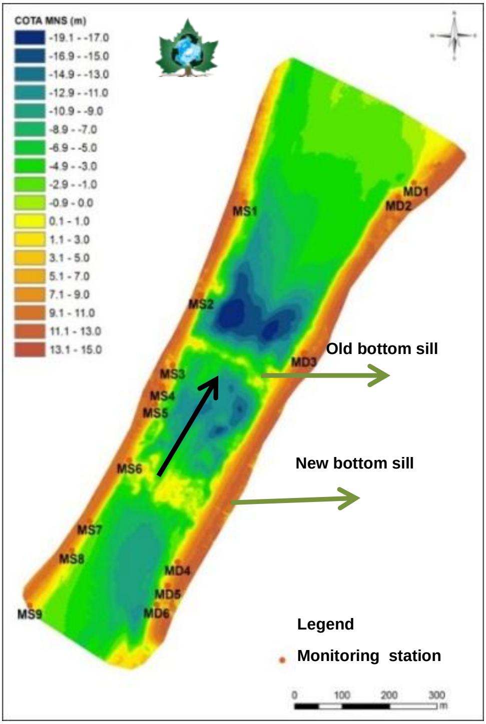


Figure 5.9 Morphology of the riverbed after the construction of NBS and the location of monitoring stations (2016)

Beluga M2

The first specimen of Beluga which crossed the NBS was M2, on March 10, 2016, at a water level of 11.87 m (recorded at Izvoarele and reported at the MNS level). From the data presented, the registered values of water velocity in the area of the two of the bottom sills have varied between 1.2 ÷ 3 m/s, the highest values being recorded in the central areas. In the monitored area of the bottom sills, M2 has recorded the most detections between the bottom sills, respectively in the area of the MS5 station with over 70% of the total. Immediately after crossing the new bottom sill, the M2 specimen has continued its upstream migration being detected by the stations located on the Danube at km 348 and km 375, where it was poached.

By correlating the behaviour of the specimen M2 with the values of the velocities recorded in the area of the two bottom sills, it can be concluded with an acceptable probability that when crossing the PFN bottom sill, it moved upstream near the left bank at water velocities between 1.2 ÷ 1.7 m/s. Next, it crossed the peak, probably through areas that offered a rest because 11 minutes it was detected on the peak, after which it passed the PFN, remaining near the left bank.

Beluga M1

The second specimen of Beluga which crossed the bottom sill was M1, on March 13, 2016, at a water level of 12.3 m (recorded at Izvoarele and reported at the MNS level). Although M1 reached the bottom sill area on February 4, 2016, before M2, it was unable to cross the OBS and subsequently the NBS, oscillating on the Bala branch with several attempts to cross the bottom sills.

At the time of crossing the Bala branch by the M1, the velocities in the cross-sections of the bottom sills were lower, compared to those recorded at the time of the crossing of M2, the differences of values recorded due to the increase of the water level by 43 cm. and the change in morphology of the cross-section in accordance with measurements made *in-situ*.

It can be noted that the M1 specimen had an oscillating behaviour with many attempts to cross the bottom sills and to leave the Bala branch area on February 9, 2016. During the period 9 - 10 March 2016, the M2 specimen was detected between the bottom sills, and the M1 downstream of the old bottom sill.

Beluga M4

The third specimen which crossed the NBS was M4, on April 23, 2016, at a water level of 8.82 m (recorded at Izvoarele and reported at MNS level). Unlike its predecessors, M4 managed to cross the bottom sill in hydrodynamic conditions with much higher flow rates, due to the low water level. During the transit period of the M4, the only area with velocity below 2 m/s was the left bank.

Beluga M3

The fourth specimen which crossed the NBS sill was M3, on April 26, 2016, at a water level of 8.62 m (recorded at Izvoarele and reported at MNS level). It is noted that the M3 also moved and stayed more on the right bank, downstream of the old bottom sill and on the left bank in the area downstream of the new bottom sill.

The study of the behaviour of the four specimens showed that the sturgeons prefer to avoid moving against high velocities of the water. In all four cases analysed finding that the crossing over the new hydro technical construction was made near the left bank, where the velocity values were lower, compared to those recorded in the same cross-section in the center and near the right bank.

Reported at the water level, the 4 specimens of Beluga passed upstream of the NBS at values between +8,62 m and +12,3 m (related to the MNS elevation), the crossing of the area was made through the bottom area of the riverbed, the section on the left bank, at water velocities less than 2 m/s.

5.5. Identification of sturgeon migration routes in the monitored sector

Between 2011 and 2017, 300 mature specimens of Beluga, Stellate and Russian sturgeons' species were captured, tagged and released. With the help of the monitoring stations, sturgeon migration routes were identified and information on the behaviour of the specimens was obtained in certain situations involving hydro-morphological changes of the riverbed.

The data obtained allowed the individual characterization of the specimens, with the biometric measurements, the capture and release areas.

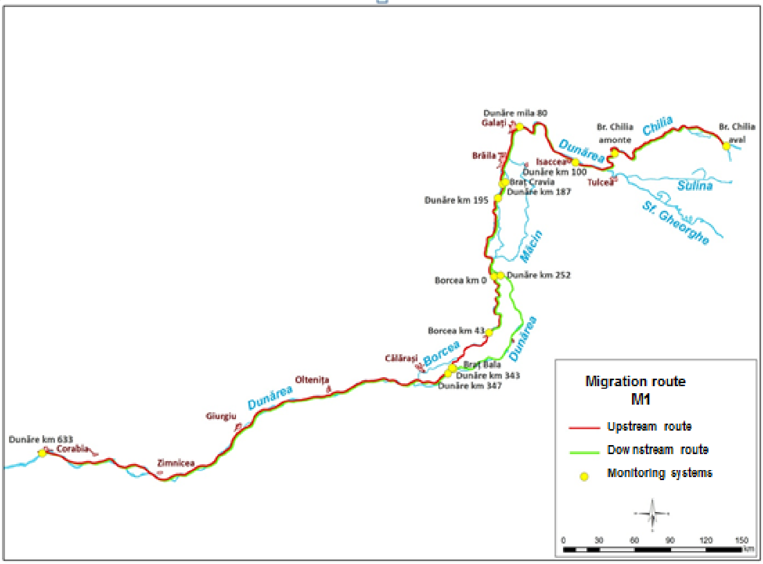
Within the thesis were presented 5 specimens of Acipenser stellatus species of which were tagged and released, the first in October 2011, then other two in June 2012 and then another two in May 2013. The spawning time was between 1 year and 3 years. 4 specimens have their migration route through the Chilia branch and the other one, probably through the Sfântu Gheorghe branch. According to the monitoring data, at present all the specimens have been poached along the route followed.

Also In the case of Belugas, five specimens were analysed. Analysed specimens showed that the period between two cycles of migration is different from one specimen to another. Two of the specimens returned to the Danube after about 4 years (M2 and M1), one after 3 years (M7), and the other two after about 5 months (M5) and 4 months (M6). From the analysis of the migration routes it resulted that two specimens were poached, the rest returned to the Black Sea after spawning on the Chilia - Stambulul Vechi branch. It is important to note that M7 reproduced on Borcea downstream of km 43 and M5 downstream of km 375.

The specific behaviour of the Beluga specimens, at the crossing of the two submerged obstacles, was oscillating for the M1 that passed the NBS after approx. 38 days from the arrival in the detection area of the monitoring stations positioned in the area of the bottom sills, and non-oscillating for the other specimens that passed through the NBS in approx. 1 day.

The following are information on biometric measurements, catch and release areas and migration routes for specimens M1 and M2.

Beluga sturgeon (*Huso huso*)	
Code	M1
Capture/release date	09.11.2011
Capture location	Borcea, km. 33-35
Release location	Borcea, km. 43
Taggs	
Ultrasonic and anti-poaching	
Biometry	
Lt: 205 cm. (Total length: centimeters)	m: 65 kg (body mass: kilogram)

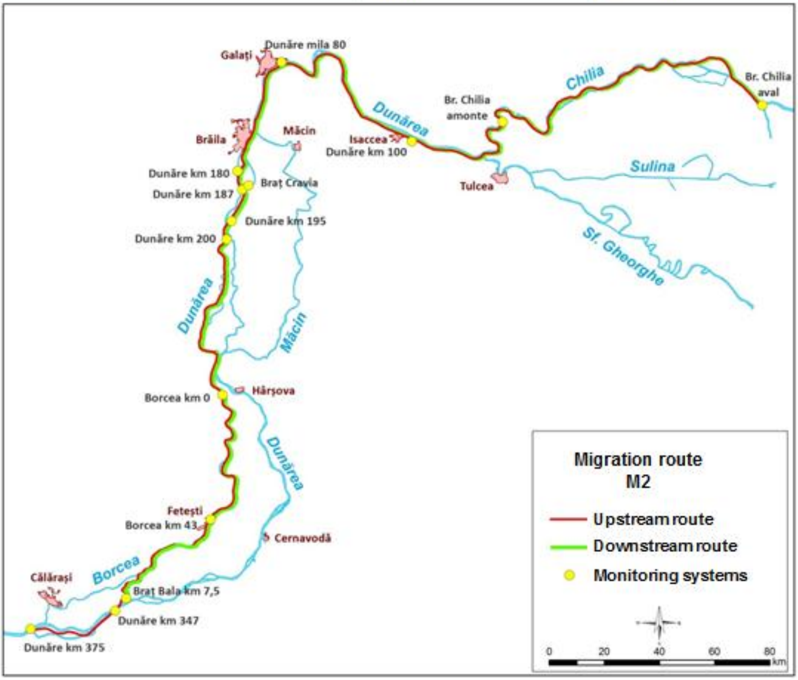


Downstream detections		
10.11.2011	14.11.2011	17.11.2011
Borcea km. 43	Dunăre km. 187	Dunăre km. 100

Upstream detections									
30.12.2015	01.01.2016	24.01.2016	26.01.2016	27.01.2016	30.01.2016	02.02.2016	04.02÷13.03.2016	13.03.2016	23.03.2016
Chilia (downstream)	Braț Chilia (upstream)	Dunăre mile 80	Cravia	Dunăre km. 195	Borcea km. 0	Borcea km. 43	Bala	Dunăre km. 347	Dunăre km. 633

Downstream detections								
09.05.2016	09.05.2016	10.05.2016	11.05.2016	11.05.2016	11.05.2016	12.05.2016	12.05.2016	13.05.2016
Dunăre km. 48	Dunăre km. 343	Dunăre km. 252	Dunăre km. 195	Braț Cravia	Dunăre mila 80	Dunăre km. 100	Chilia (upstream)	Chilia (downstream)

Beluga sturgeon *(Huso huso)*	
Code	M2
Capture/release date	03.11.2011
Capture location	Borcea, km. 45-47
Release location	Borcea, km. 43
Taggs	
Ultrasonic and anti-poaching	
Biometry	
Lt: 210 cm. (Total length: centimeters)	m: 70 kg (body mass: kilogram)



Downstream detections		
05.11.2011	29.04.2012	30.04.201
Bala km. 7,5	**Borcea km. 64**	**Dunăre km. 187**
30.04.2012	01.05.2012	
Dunăre km. 180	**Dunăre km. 100**	

Upstream detections					
11.02.2016	14.02.2016	16.02.2016	18.02.2016	21.02.2016	22.02.201
Braț Chilia (downstream)	**Chilia (upstream)**	**Dunăre km. 100**	**Dunăre mile 80**	**Cravia**	**Dunăre km. 195**
22.02.2016	27.02.2016	08.03.2016	09-10.03.2016	10.03.2016	1.03.201
Dunăre km. 200	**Borcea km. 0**	**Borcea km. 43**	**Bala**	**Dunăre km. 347**	**Dunăre km. 375**

CHAPTER VI ANALYSIS OF THE ANTHROPIC FACTORS INFLUENCING THE MIGRATION AND THE CONSERVATION STATE OF THE STURGEON SPECIES FROM LOWER DANUBE

One of the important anthropic factors, which may influence the movement of sturgeons in the Lower Danube, is the construction of the new bottom sill (NBS) in the Bala branch area at km 9.7 upstream of the old bottom sill made in the 1980s. In order to evaluate the degree of influence of the NBS, it was necessary to monitor the area between the Izvoarele (at the entrance), the Bala branch (at the entrance km 10, respectively km 9.5 at the exit) and the Old Danube (at the entrance, at the confluence and at km 342 at the exit) where the hydrodynamic and hydro morphological conditions were analysed, from the migration area during pre and post hydro technical construction.

6.1 Comparative study on the hydrodynamic and hydro morphological parameters before and after the construction of the new bottom sill on the Bala branch

During the monitoring period, detections were recorded at the monitoring stations, located in the area of interest, from 30 specimens of ultrasonic tagged sturgeons, which moved during their migration either on the Cernavodă - Izvoarele (Old Danube) route or on the Borcea - Bala - Old Danube (Izvoarele). Data presented in Table 6.1.

Table 6.1 Upstream migration of sturgeons on the Bala branch and on the Old Danube 2011÷2017

Nr. crt.	Specie	CODE	Date tagged	Place of release	Date crossing Bala branch	Date of registration at the Danube 252 km.	Date of registration at the Danube 347
1	*H. huso*	M2	03.11.2011	Brațul Borcea km. 45	11.03.2016		11.03.2016
2	*H. huso*	M8	09.11.2011	Brațul Borcea km. 43	18.11.2011		23.11.2011
3	*H. huso*	M1	09.11.2011	Brațul Borcea km. 43	13.03.2016		23.03.2016
4	*H. huso*	M9	29.11.2011	Brațul Bala km. 9	14.12.2012		
5	*H. huso*	M10	07.12.2011	Brațul Bala km. 8	03.03.2012		
6	*H. huso*	M11	27.03.2012	Brațul Borcea km. 65	02.04.2012		
7	*H. huso*	M12	24.05.2012	Brațul Borcea km. 57	08.11.2014		08.11.2014
8	*H. huso*	M13	30.11.2012	Brațul Borcea km. 7	07.12.2015		07.12.2015
9	*H. huso*	M5	31.10.2013	Brațul Borcea km. 50	12.03.2014		13.03.2014
10	*H. huso*	M14	11.11.2013	Brațul Borcea km. 3,5		19.03.2014	21.03.2014
11	*H. huso*	M15	26.11.2013	Brațul Borcea km. 43	12.11.2015		12.11.2015
12	*H. huso*	M16	19.03.2014	Brațul Borcea km. 43		24.04.2014	
13	*A. stellatus*	P6	26.04.2014	Brațul Caleia km. 9		11.05.2014	16.05.2014
14	*A. stellatus*	P7	28.04.2014	Brațul Caleia km. 9		07.06.2014	12.06.2014
15	*A. stellatus*	P8	08.05.2014	Brațul Bala km. 9,8	20.05.2014		
16	*A. stellatus*	P9	11.05.2014	Brațul Bala km. 9,8	18.05.2014		18.05.2014
17	*A. stellatus*	P10	13.05.2014	Brațul Bala km. 9,8	26.05.2014		
18	*A. stellatus*	P11	28.04.2015	Dunăre km. 197		22.05.2015	26.05.2015
19	*A. gueldenstaedtii*	N12	02.05.2015	Brațul Borcea km. 43,5	27.05.2015		27.05.2015
20	*A. stellatus*	P12	04.05.2015	Dunăre km 197		27.05.2015	31.05.2015
21	*A. stellatus*	P13	05.05.2015	Brațul Borcea km. 43.5		20.05.2015	23.05.2015
22	*H. huso*	M17	02.11.2015	Brațul Borcea km. 0	12.11.2015		12.11.2015
23	*H. huso*	M18	09.11.2015	Brațul Borcea km. 43	13.11.2015		13.11.2015
24	*H. huso*	M19	13.11.2015	Brațul Borcea km. 43	15.11.2015		15.11.2015
25	*H. huso*	M3	15.11.2015	Brațul Borcea km. 42.5	26.04.2016		26.04.2016
26	*H. huso*	M4	18.11.2015	Brațul Borcea km. 42.5	23.04.2016		23.04.2015
27	*A. stellatus*	P14	06.09.2016	Brațul Borcea km. 43		12.09.2016	
28	*H. huso*	M22	28.11.2016	Brațul Borcea km. 43	25.04.2017		25.04.2017
29	*A. stellatus*	P16	02.09.2017	Brațul Borcea km. 43	25.09.2017		25.09.2017
30	*H. huso*	M23	01.11.2017	Brațul Borcea km. 43	21.03.2017		21.03.2017

Table 6.2 presents the hydrodynamic parameters recorded on the Bala branch, respectively on the Old Danube, during the period of movement of the 22 monitored specimens, obtained by measurements performed in the field, using the ADCP technique.

Table 6.2 Quantitative water parameters recorded during the migration period of the specimens

Nr. crt.	Specie	CODE	Date crossing Bala branch	Discharge (m^3/s) Dunăre km 348	Discharge (m^3/s) Dunăre km 344,5	Discharge (m^3/s) Bala	Average velocity on NBS (m/s)
1	*H. huso*	M10	03.03.2012	4316	1296	3020	0,83
2	*H. huso*	M8	18.11.2011	2792	530	2262	1,03
3	*H. huso*	M9	14.12-2011 19.05.2012	6361	2411	4792	0,96
4	*H. huso*	M11	02.04.2012	5969	2179	3790	1,01
5	*H. huso*	M12	08.11.2014	7616	3275	4341	2,53
6	*H. huso*	M5	12.03.2014	6674	2736	3938	2,25
7	*A. stellatus*	P9	18.05.2014	9118	4213	4905	2,15
8	*A. stellatus*	P8	20.05.2014	10069	4732	5337	1,96
9	*A. stellatus*	P10	26.05.2014	11271	5613	5658	1,81
10	*A. gueldenstaedtii*	N12	27.05.2015	5505	2075	3430	2,5
11	*H. huso*	M17	12.11.2015	3783	1135	2648	2,19
12	*H. huso*	M15	12.11.2015	3783	1135	2648	2,19
13	*H. huso*	M18	13.11.2015	3783	1135	2648	2,31
14	*H. huso*	M19	15.11.2015	3474	973	2501	2,21
15	*H. huso*	M13	07.12.2015	4751	1554	3017	2,64
16	*H. huso*	M2	10.03.2016	9451	4442	5009	2,27
17	*H. huso*	M1	13.03.2016	10085	4740	5345	1,93
18	*H. huso*	M4	23.04.2016	5586	1983	3603	2,42
19	*H. huso*	M3	26.04.2016	5367	1895	3472	2,47
20	*H. huso*	M23	21.03.2017	7450	3097	4353	2,49
21	*H. huso*	M22	25.04.2017	4636	1528	3108	2,39
22	*A. stellatus*	P16	25.09.2017	3462	977	2485	2,02

From the presented data it is observed that the sturgeons can move to the habitats upstream of the area of the new NBS hydro construction, although the hydro technical works involved changes on the hydrodynamic parameters and shape of the riverbed through erosion and sediment deposits, both on the Bala branch and on the Old Danube.

The processing of the data obtained by bathymetric measurements in the field, for the case of the two scenarios, highlighted the hydro morphological changes that occurred following the construction of the new bottom sill in the area of the Bala branch. Figure 6.1 shows the two situations, analysed from the morphological point of view.

It is noteworthy that there is a historical impact due to the old bottom sill, located 600 m from the Bala branch - Old Danube, which at the level of 2012 and until June 2013 can be considered as part of the structure of the Bala branch and consumed the hydro morphological and hydrodynamic effect. With the beginning of the NBS construction, the morphology of the riverbed began to change and the hydrodynamic regime changed in the area.

In the intensive monitoring campaigns, carried out during the entire execution period of the hydro technical works, to provide a database necessary for the comparative analysis in time of the hydrodynamic and hydro morphological parameters, 3 longitudinal control sections were defined (SMD1 - the control section in the right bank area, SC2 - the control section in the centre area and SMS3 - the control section in the left bank area) and two cross sections defining 3 control points for NBS and 3 control points for OBS (Figure 6.2).

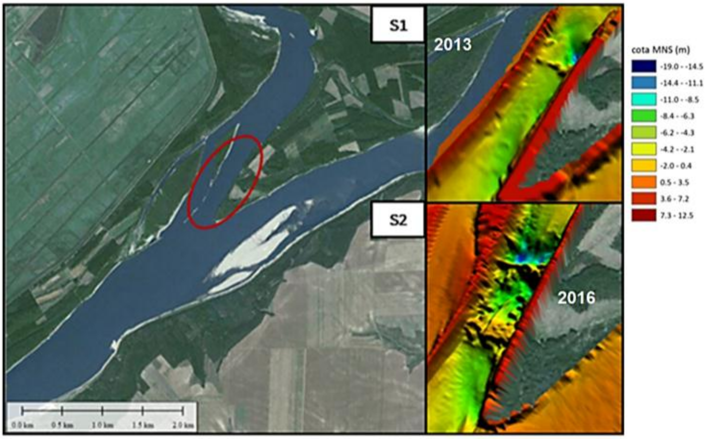


Figure 6.1 Bala branch riverbed morphology

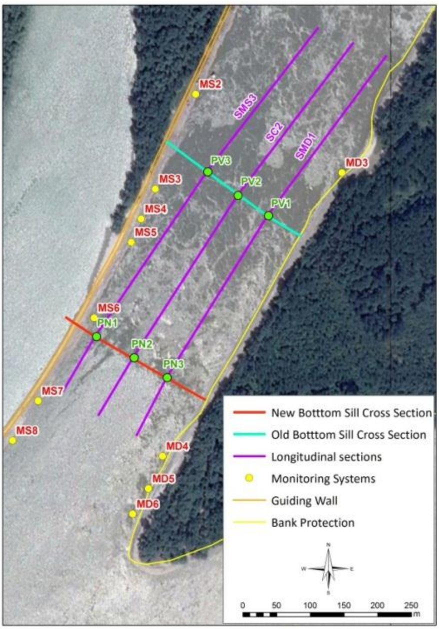
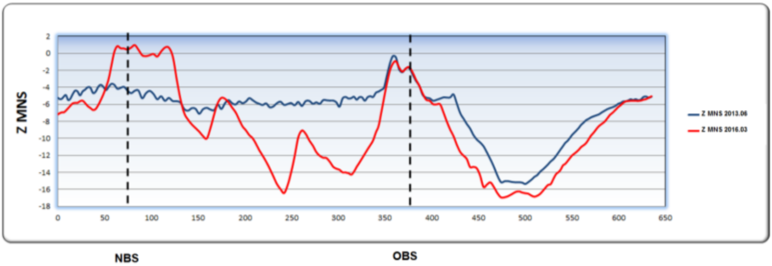


Figure 6.2 Map of section and control points

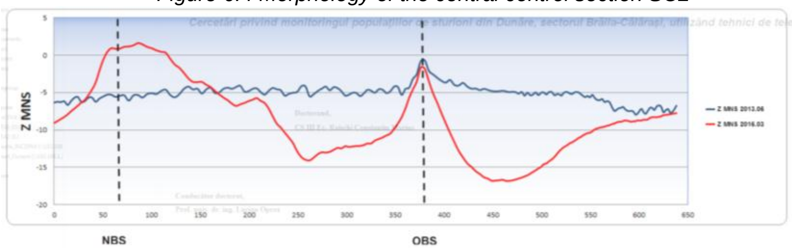
For the comparative analysis, the control section SMD1 is presented near the right bank, in Figure 6.3, where the hydro morphological evolution of the area of interest can be observed before the NBS (blue line) construction and after its construction (red line).

Figure 6.3 Section SMD1 – right bank



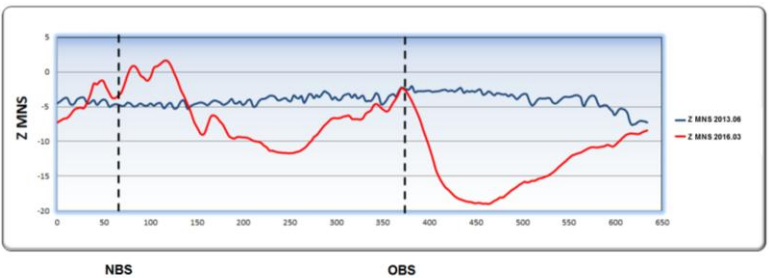
For the comparative analysis, the control section SC2 from the centre of the Bala branch is presented (Figure 6.3), where the hydro morphological evolution of the area of interest can be observed before the NBS (blue line) construction and after its completion (red line). Major erosion occurred both upstream and downstream of the NBS and reactivated the OBS much more intensely, creating a scour pit downstream at over 10 m deep.

Figure 6.4 Morphology of the central control section SC2



For the comparative analysis, the control section SMS3 is presented near the left bank (Figure 6.3), where the hydromorphological evolution of the area of interest can be observed before the NBS (blue line) construction and after its construction (red line). From the graph it is observed the formation of erosion upstream and downstream of the new bottom sill and the reactivation of the old one, which created downstream a scour pit of 15 m deep.

Figure 6.5 Morphology of control section SMS3 – left bank



Analysing the velocity distribution of the water stream in longitudinal profile, it can be observed that, after the completion of the new NBS construction, the frequency of the high velocities is lower on the section near the left bank (SMS3), compared to the middle profile (SC2).

6.2. The influence of poaching on the conservation status of sturgeon species

During the monitoring period of ultrasonic tagged sturgeons, poaching negatively influenced the research results. Manifested in different forms (Figure 6.6), poaching contributed to the loss of over 70% of the total number of tagged specimens. Therefore, only 76 specimens, of the 300 tagged (belonging to the 3 species of anadromous sturgeons from the Lower Danube) survived until the end of 2017 (Table 6.3).

Table 6.3 Poached specimens

Perioada CAMPANIA		Pastrugă			Morun			Nisetru		
		Total capturi	Braconaj	Posibil braconaj	Total capturi	Braconaj	Posibil braconaj	Total capturi	Braconaj	Posibil braconaj
2011	I	15	8	6	0	0	0	0	0	0
	II	2	1	1	25	2	22	1	0	1
2012	I	35	14	20	9	4	4	0	0	0
	II	1	0	1	4	0	3	0	0	0
2013	I	24	14	10	0	0	0	0	0	0
	II	6	0	6	13	0	6	1	0	0
2014	I	44	25	7	4	0	2	1	0	1
	II									
2015	I	44	29	5	3	0	1	1	0	0
	II	5	0	4	10	0	4	0	0	0
2016	I									
	II	4	3	0	31	1	14	1	0	0
2017	I									
	II	9	5	0	5	0	0	2	0	0
TOTAL		189	99	60	104	7	56	7	0	2

Total sturgeons	300
Poached	106
Possible poached	118
Total poached	224
Monitored sturgeons	**76**

Figure 6.6 Poached specimen

Evidence to this effect is shown in Figure 6.7. From the records of the station located on the Borcea branch at km 3, we observed multiple detections of a mature specimen of the species *Acipenser stellatus*, tagged in the spring of 2014, which indicated its presence for a long time on the surface of the water, which is not corresponds to the usual behaviour of fish.

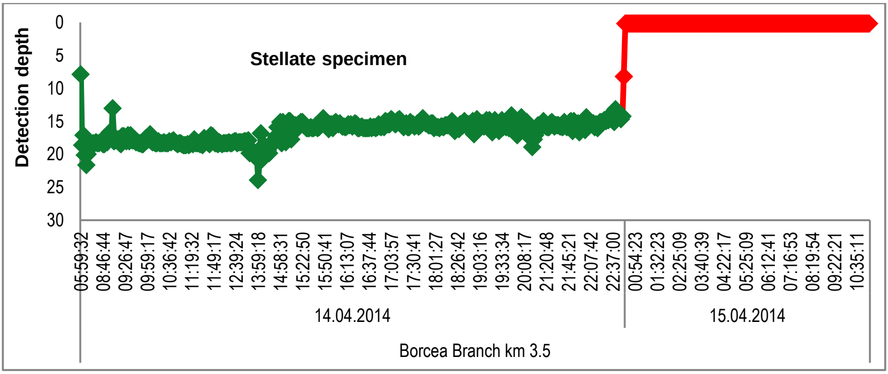


Figure 6.7 Interpretation of data recorded with the help of the monitoring station and confirmation of poaching

The unusual behaviour of the Stellate, on April 15, 2014, is proof that poachers captured the specimen, removed the ultrasonic tagged and let it float in the Danube River, in a plastic container (Figure 6.8).

Figure 6.8 *Identification of the ultrasonic tags floating in the Danube in plastic containers*

Figure 6.9 and Figure 6.10 show the number of specimens monitored each year of research and those that can be detected until the life time of battery implanted on sturgeon specimens will expired.

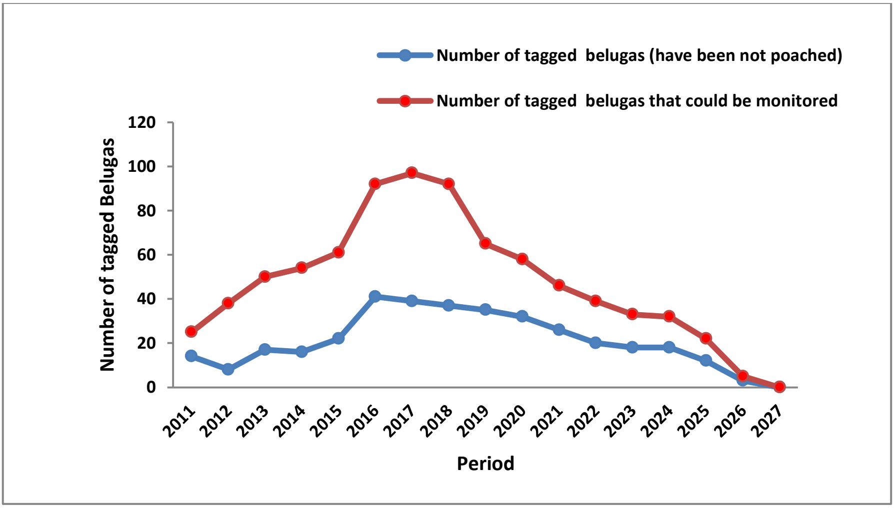


Figure 6.9 Number of monitored Beluga sturgeons (Raischi & Deak, 2018)

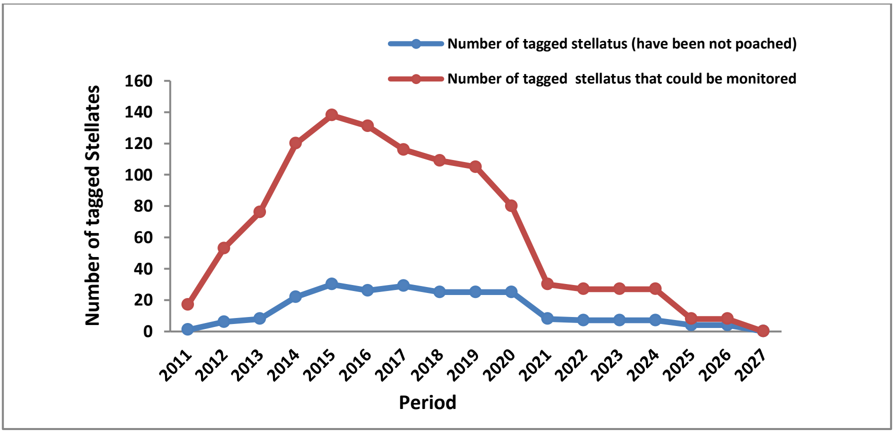


Figure 6.10 Number of monitored Stellate sturgeons (Raischi & Deak, 2018)

According to the graphs in Figures 6.13 and 6.14, it can be concluded that in 2017 the most *Huso huso* specimens were monitored, in number of 97. However, the real situation was greatly influenced by poaching, so that only 40% of the specimens were monitored during that year. For *Acipenser stellatus*, the year 2015 should have been the year with the most monitored specimens, in number of 138, but due to poaching, in 2015, only 30% of the tagged specimens were monitored.

CHAPTER VII GENERAL CONCLUSIONS, PERSONAL CONTRIBUTIONS AND PERSPECTIVES

The studies and research presented indicate that on the Romanian territory it is possible that the wild sturgeon population can only be represented by 4 species, out of the 6 previously existing in the Danube. The conservation status of the four species of sturgeons that are still living in the Danube is:

- Beluga sturgeon (*Huso huso*) - critically endangered species
- Russian sturgeon (*Acipenser gueldenstaedtii*) - critically endangered species
- Stellate sturgeon (*Acipenser stellatus*) - critically endangered species
- Sterlet sturgeon (*Acipenser ruthenus*) - vulnerable species

In order to identify the most appropriate protection measures of the sturgeon species, it is necessary to evaluate and analyse the anthropic pressures with an impact on the conservation status of the species. For these reasons, the doctoral thesis aimed to study the impact of anthropic pressures on the conservation status and on the migration of the sturgeons in the Lower Danube, based on a unique information volume, obtained through activities supported by *in situ* measurements for 7 years. The results obtained, which reflect the concrete situation, are based on investigations of a unique nature at European level, which required a very large volume of work and a constant long-term effort, regardless of the season.

Some of the raw data analysed in the thesis, regarding the number of catches, tagging, the release and the monitoring of the specimens, were obtained through investigations within the projects of monitoring the environmental factors carried out by INCDPM for several years, starting with 2011 and which is still ongoing. Within these projects, the author of the thesis, one of the research team members and responsible for carrying out field activities on the Danube, had the following: **OWN SCIENTIFIC CONTRIBUTIONS:**

1.Choosing the most appropriate methods for tagging sturgeon specimens, for later monitoring

In choosing the methods of tagging sturgeon specimens, the author has analysed the existing information and the current state of the art worldwide, so that the chosen methods to be the most suitable for the monitored fish species, respectively minimally invasive so as not to affect the integrity of the specimens, but also the most suitable for long-term monitoring, in the hydrodynamic conditions specific to the Lower Danube.

The author also considered the use of the additional tagging with external labels "spaghetti" necessary in case of accidental capture of the tagged and monitored specimens, to draw the attention that the specimen is part of a research project, therefore increasing the chances that it will be released into their natural environment.

2.Contributions to the development of innovative sturgeon monitoring systems

In order to reach the proposed objectives of the thesis, continuous monitoring of the specimens was required. For that reason the reliability of the equipment used was considered a decisive factor in the choice of monitoring types of equipment, the loss of the detection receivers was considered equivalent to the loss of data.

Type III and IV systems, developed in part in the present thesis, are the subject of the patents RO128559 / 2018 and RO 129803/2017 presented in Figure 7.1, Figure 7.2.

ROMÂNIA

OFICIUL DE STAT PENTRU INVENȚII ȘI MĂRCI

BREVET DE INVENȚIE

Nr. 128559

Acordat în temeiul Legii nr.64/1991 privind brevetele de invenție, republicată în Monitorul Oficial al României, Partea I, nr.613, din 19 august 2014.

Titular: INSTITUTUL NAȚIONAL DE CERCETARE-DEZVOLTARE PENTRU PROTECȚIA MEDIULUI, BUCUREȘTI, B, RO

Titlul invenției: STAȚIE DE MONITORIZARE A IHTIOFAUNEI ȘI ÎN SPECIAL A STURIONILOR, PRIN TELEDETECȚIE CU MARCĂ ULTRASONICĂ ÎN DIFERITE CONDIȚII HIDROLOGICE

Inventatori: DEAK GYORGY, BĂLAN, HR, RO; TĂNASE BOGDAN, NICULEȘTI, DB, RO; BĂDILIȚĂ ALIN, BUCUREȘTI, B, RO; RAISCHI MARIUS, BUCUREȘTI, B, RO; TĂNASE GEORGIANA SIMONA, CĂLĂRAȘI, CL, RO

Descrierea invenției, revendicările și desenele la care se face referință în acestea, fac parte integrantă din prezentul brevet de invenție.
Durata brevetului de invenție este de 20 ani, cu începere de la data de 30/10/2012, cu condiția plății taxelor anuale de menținere în vigoare a brevetului.

Confirm cele de mai sus prin semnarea și aplicarea sigiliului
Director General

București, Data eliberării 30/10/2018

Figure 7.1 Patent for the mobile monitoring station

ROMÂNIA

DUPLICAT
ELIBERAT INVENTATORULUI
în baza Art.34 alin.(2),
din Legea nr.64/1991 republicată

OFICIUL DE STAT PENTRU INVENȚII ȘI MĂRCI

Brevet de invenție

Nr. 129803

Acordat în temeiul Legii nr.64/1991 privind brevetele de invenție, republicată în Monitorul Oficial al României, Partea I, nr.613, din 19 august 2014.

Titular: INSTITUTUL NAȚIONAL DE CERCETARE-DEZVOLTARE PENTRU PROTECȚIA MEDIULUI, BUCUREȘTI, B, RO

Titlul invenției: STAȚIE MOBILĂ DE MONITORIZARE PRIN TELEDETECȚIE A IHTIOFAUNEI ȘI ÎN SPECIAL A STURIONILOR ÎN CONDIȚII HIDROLOGICE DIFICILE

Inventatori: DEAK GYORGY, BĂLAN, HR, RO; RAISCHI NATALIA SIMONA, BUCUREȘTI, B, RO; BĂDILIȚĂ ALIN MARIUS, BUCUREȘTI, B, RO; RAISCHI CONSTANTIN MARIUS, BUCUREȘTI, B, RO; SILION MARIUS MĂDĂLIN, BUCUREȘTI, B, RO; TUDOR MARIAN, TULCEA, TL, RO

Descrierea invenției, revendicările și desenele la care se face referință în acestea, fac parte integrantă din prezentul brevet de invenție.
Durata brevetului de invenție este de 20 ani, cu începere de la data de 02/04/2014, cu condiția plății taxelor anuale de menținere în vigoare a brevetului.

Confirm cele de mai sus prin semnarea și aplicarea sigiliului
Director General

București, Data eliberării 28/02/2017

Figure 7.2 Patent for the fixed monitoring station

The two monitoring systems, although simple in construction and easy to manufacture, have provided high reliability in the period of *in-situ* monitoring, reducing/eliminating the losses of a unique information volume at European level.

3. Analysis of catches

Between May 2011 and December 2017, 300 specimens of the *Huso huso* (104 specimens), *Acipenser stellatus* (189 specimens) and *Acipenser guldenstaedti* (7 specimens) were captured and released in the Danube, activities in which the author has participated.

In the case of the *Huso huso*, the growth was estimated, by the dimension of specimens, before of age determination, due to some errors in weighing, the part of the date had to be corrected. The results regarding the number of specimens and their age in the analysed sample are presented in Figure 4.16.

In the case of the *Acipenser stellatus*, due to the smaller size of the specimens, their weighing could be done with high precision, without requiring corrections, the growth analysis is presented in Figure 4.18.

For the Acipenser gueldenstaedtii species, the age of the specimens could not be estimated, due to the small number of catches, of approx. 2% of the total. It can be concluded that the Russian sturgeon, a species considered in the past to be the most abundant in the Danube basin, in comparison with the other species of sturgeons, in the current period is in critical danger of extinction.

4.Sturgeon monitoring activities (for identifying general and specific behaviour)

The data regarding the detections of the specimens recorded by the stations located in the sector between km 633 of the Danube and the Black Sea were downloaded at terms established by the author, which allowed the processing of information, but also the maintenance of the equipment.

Monitoring of sturgeon habitats and migration involves, among other, determination of water and sediment quality, hydrodynamic and hydro morphological conditions, as well as evaluation of general and specific sturgeon behaviour, identification of migration routes and spawning areas, taking into account the Aarhus Convention.

In order to achieve an informational volume with a high level of confidence, also to evaluate the behaviour of sturgeons and migration routes and implicitly the spawning areas, fixed and floating monitoring stations have been placed on 600 km route along the Danube, including the branches through which the river flows into the Black Sea. The purpose of the monitoring was to identify, in particular, the general behaviour and sturgeon migration routes, as well as to ensure the reception range throughout the area of interest on Bala branch - km 9.5 - the bottom sill, where there are areas with swirls disrupting the reception signal. The stations were positioned from 50 m to 50 m on both banks (15 in number) in order to evaluate the specific behaviour of sturgeons during their movement over submersible obstacles.

In order to determine the general and specific behaviour, in the presence of a submerged obstacle, the specimens of Beluga M1, M2, M3 and M4 were studied, with the following general conclusions regarding the behaviour of this species from the Lower Danube:

a) the movement of the Beluga specimens showed that they prefer different depths, depending on the type of upstream or downstream movement [40], usually high depths upstream and small downstream, a situation confirmed by M1, M2 and M3 and denied by the M4 who behaved atypically, preferring great depths for moving in both directions of swimming;
b) all specimens were detected in real-time, with the VR100 mobile device, on the section upstream of the Bala branch area. Analysing the detection in real-time, the author identified the possibility of scour pits, used by sturgeons for feeding, resting, wintering or possibly spawning. Under these conditions, research campaigns were carried out using 3D bathymetric measurements, to analyse the morphology of the Bala branch in the areas where ultrasonic tagged belugas were detected. Figure 7.3 and Figure 7.4 show the morphology of the scour pits identified on the migration path of the ultrasonic tagged specimens, respecting the Aarhus Convention on the protection of endangered species;
c) out of the 4 species of Beluga, only M2 spawning without swimming downstream into the Black Sea and which, after returning to the Danube, was poached at km 375;
d) in their migration, 3 specimens used the Chilia branch, of which M3 used the Chilia branch combined with the Bâstroe canal, the other two combined the Chilia branch with the Stambulul Vechi channel, and M4 used the Sulina branch;

e) 2 specimens after spawning downstream of km 633 (M1 and M4) returned on the migration route Old Danube (M1) - the Chilia-Stambulul Vechi branch and the Bala branch (M4) – Chilia-Stambulul Vechi, respectively the one that spawning downstream of km 375 (M3) returned on the Bala branch route - the Chilia-Bâstroe channel branches;

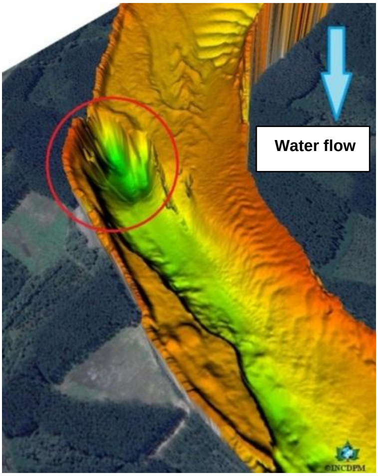


Figure 7.3 Bala branch, 3D view of Area1

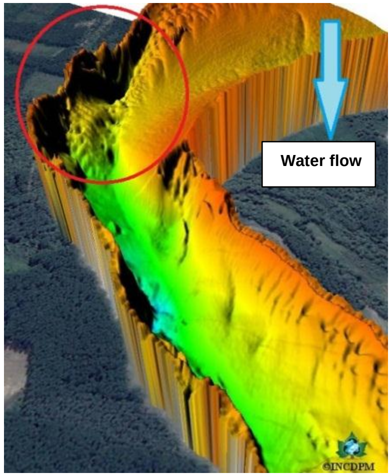


Figure 7.4 Bala branch, 3D view of Area2

f) the specific behaviour of the Beluga specimens, at the crossing of the two submerged obstacles, was oscillating for the M1 that passed the NBS after approx. 38 days from the arrival in the detection range of the monitoring stations positioned in the area of the bottom sills, and non-oscillating for the other specimens that passed through the NBS in approx. 1 day

g) all 4 specimens used the left bank for crossing the current configuration of the bottom sills, with the exception that M2 and M4 passed the bottom sill peak, located at the 0 MNC level, near the left bank, and M1 and M3 have crossed diagonally to the right bank;

h) in the event that the specimens seek the most suitable areas to overcome the submerged obstacles, for which it allocates sufficient effort for success, with intermediate rest, it turns out that the greatest effort was made by M1, who passed diagonally the peak of the bottom sill, the other specimens have an effort of less than 50% than M1;

i) analysing the migration routes over the NBS from the data held, the author concluded that, apart from M1, M3 has passed with 87% reduced effort up the left bank and 13% higher effort when crossing the NBS. The M4 had 23% reduced effort and 67% high effort, respectively the M2 had 21% reduced effort and 79% high effort.

From the analysis of the specific behaviour of the Beluga sturgeons, when they have crossed submerged obstacles, it could be identified that 75% have passed practically the bottom sills built on the Bala branch, and 25% have had difficulties with both OBS and NBS, but in finally they exceeded the submerged obstacles under the conditions of the peak at 0 MNC and the current geometry of the NBS.

Concerning sturgeon migration, five complex maps were made for each specie Beluga and Stellate sturgeons with migration routes and information characteristic:

- The 5 specimens of Stellate were tagged and released: one on October 2011, two in June 2012 and the other two in May 2013. The return for the spawning cycle was between 1 year and 3 years. 4 specimens had used the route through the Chilia branch and one of them, probably through the Sfântu Gheorghe branch. According to the migration routes, at present, all the specimens are poached along the followed route;
- In the case of Beluga sturgeons, the five analysed specimens showed that the period between two migration cycles is different from one specimen to another. Two of the specimens returned to the Danube after about 4 years (M2 and M1), one after 3 years (M7), and the other two after about 5 months (M5) and 4 months (M6). From the analysis of the migration routes it resulted that two specimens were poached, the rest of the specimens returned to the Black Sea after spawning on the Chilia - Stambulul Vechi branch. It is important to note that M7 spawned on Borcea downstream of km 43 and M5 downstream of km 375.

Also is important to mention the procedure introduced by the author, together with the INCDPM team, regarding the mandatory monitoring of the behaviour of ultrasonic tagged sturgeons. Therefore, from the moment when the presence of a sturgeon coming from the Black Sea is identified in Danube, the monitoring campaign of the specimen begins. The procedure implies the alert by the alarm station located at the Feteşti Working Point and detection with the VR100 mobile device. Due to this procedure important information was obtained on April 21, 2016, when two Beluga sturgeons, respectively M3 and M4, were in the area of km 6 on the Bala branch, between the hours of 12:26 ÷ 12:43. Strict monitoring of tagged specimens also aims to protect them against poaching.

5.General analysis of sturgeon migration on the Bala and Old Danube branch

Comparing the behaviour of the **300 adults specimens**, respectively **76 specimens** (out of the total number of catches about **75% were poached**) of the migratory species of Beluga, Russian, and Stellate sturgeons, captured between April 2011 and December 2017, the degree of use Danube's branches could be appreciated during the upstream migration.

Of the total sturgeon tagged there were 22 specimens that migrated upstream on the Bala branch, and only 8 specimens on the Old Danube, of which only 6 passed above km 252 of the Danube. The low number of migrations upstream of the Bala area was largely caused by poaching and lack of scientific fishing authorization, which diminished the chances to tag more sturgeon specimens.

The author notes that in 2013 were measured velocities up to maximum 2,2 m/s, values recorded in the old bottom sill area, both on the surface of the water and in the area of the river (**right bank**), up to maximum 2,0 m/s, values recorded in the old bottom sill area, on the surface of the water and 1,8 m/s in the riverbed area (**in the centre**), respectively up to a maximum of 2,2 m/s, values recorded in the old bottom sill area, at the water surface and in the area of the riverbed (**left bank**). At the level of 2016, the value of the velocities increased in the area of the new bottom sill with over 2,2 m/s, also reaching 2,8 m/s (**right bank**) and with values over 3,0 m/s at the riverbed, reaching 3,2 m/s at the surface water (**in the center**) respectively with values of over 2,8 m/s at the riverbed and at the water surface (**left bank**) at the flow discharge at which the measurements were made.

From the hydro morphological comparative analysis (2013 before the execution of the NBS vs. the year 2016 after the execution of the NBS) it was found that the construction of the NBS has reactivated the OBS, so that at present it cannot talk about the eventual impact of the NBS. A complex situation has been created that includes an active scour pit generated by the funnel effect upstream of the NBS, the two bottom sills together with the scour pit between them and, finally, the scour pit downstream of the OBS. At the present level, this complex called the Bala problem does not have a significant impact on the sturgeon migration, but the risk is that in time, due to the changes in the investigated area, problems will arise and these could interrupt the migration route.

6. Highlighting the poaching phenomena

Following the data processing conducted by the author, and recorded by the monitoring equipment located in the field, the impact of poaching on the species of sturgeons was highlighted. Throughout the monitoring period, poaching has contributed to the loss of over 70% of the total number of ultrasonic tagged specimens. Furthermore, it could be affirm with a high level of confidence that only 76 specimens, of the 300 tagged (belonging to the 3 species of anadromous sturgeons from the Lower Danube) had survived until December 2017. The author found that the risk of poaching increases with the number of spawning cycles. Moreover, the impact of poaching was also reflected in the thesis results by reducing the number of monitored sturgeons. In Figure 6.9 and Figure 6.10 are presented for *Huso huso* and *Acipenser stellatus* species, the number of specimens monitored in each research year and those that can be detected until the expiry of the tags battery life implanted into the sturgeon specimens.

It can be concluded that poaching has greatly influenced the results of the research study, by reducing the number of monitored specimens and implicitly by increasing the degree of uncertainty. Therefore, it can be mentioned that at the level of the year 2017, taking into account the possible number of sturgeons left after poaching, a 40% efficiency was observed in the study of the specimens that moved upstream in the area called the Bala problem and a ratio of 29% for those who are directly influenced by the Bala branch.

In order to continue the study carried out within the thesis, the author has proposed the following **POTENTIAL RESEARCH DIRECTIONS.**

In order to identify the most suitable sturgeon protection measures, it is necessary to evaluate the stocks, together with the analysis of the anthropic pressures with an impact on the conservation status of the species.

It is necessary to improve the mobile and fixed monitoring stations, respectively their adaptation to an online data transmission system.

Regarding the migration of sturgeons from the Lower Danube, at present, the author together with other experts within the INCDPM continue the activities of ultrasonic tagging and monitoring of anadromous sturgeons specimens, in order to supplement the already existing database.

The monitoring of the specimens in order to identify the impact of the hydro technical construction allowed to obtain important information regarding the sturgeon behaviour regarding the movement against high water currents. However, given that the results presented in the thesis were obtained under certain hydrological conditions, it is important that the monitoring of the specimens and the Bala area to continue for a longer period of time, in order to identify the behaviour of sturgeons in other situations that involve increasing or decreasing of the water flow.

Considering the purpose for which the new bottom sill (NBS) was built and considering that the effect of the hydro technical construction was negative, worsening the navigation conditions and not meeting the cooling water requirement for the Cernavoda Nuclear Power Plant, the author considers that a *win-win* engineering solution must be developed, which will ensure migration routes for sturgeons, but also solve the problems related to navigation and ensuring the required cooling water flow for the Cernavoda Power Station, in drought conditions.

The author considers that the Bala problem should be intensively monitored in the future, because there is a risk that, while the area is stabilized, morphological changes will occur that will affect sturgeon migration routes.

Last but not least, as a long-term perspective, the author considers necessary: to identify the possibilities of poaching reduction and to evaluate the efficiency of the restocking programs, so that the conservation status of the Lower Danube sturgeon species can be improved.

LIST OF PUBLICATIONS PRESENTED AT SCIENTIFIC EVENTS

ISI listed Publications

1. **M. C. Raischi**, L. Oprea, G. Deák, M. Boboc , M. Matei, N. Raischi, 2017. „Investigation of sturgeon migration routes using the most adequate monitoring techniques in difficult hydrological conditions of the Danube River", Journal of environmental protection and ecology, volume:18, issue: 1, pages:142-157,
http://www.jepe-journal.info/journal-content/vol-18-no-1

2. **M. C. Raischi**, L. Oprea , G. Deák, A. Badilita, M. Tudor, 2016, „Comparative study on the use of new sturgeon migration monitoring systems on the lower Danube", Environmental Engineering and Management Journal(EEMJ), volume:15, issue:5, pages:1081-1085
http://www.eemj.icpm.tuiasi.ro/pdfs/vol15/no5/17_156_Raischi_15.pdf

3. T. M. Danalache, A. M. Badilita, G. Deak, E. Holban, I. Popescu, A. Daescu, **M.C. Raischi,** G. Ghita, C. G. Nicolae, S. Diaconescu, 2017. „Assessment of Bastroe Channel possible impact on Lower Danube sturgeon migration", AACL Bioflux, volume:10, issue:5, pages:1011-1018
http://www.bioflux.com.ro/docs/2017.1011-1018.pdf

4. A. F. Nicolae, G. Deák, T. Georgeta, C. Cirstinoiu, S. Zamfir, B. Uritescu, G. Lucian, G. Ghita, **M.C. Raischi**, A. Daescu, 2017. „Comparative analysis on water velocity distribution in the context of riverbed morphology changes and discharge variation", Journal of Environmental Protection and Ecology(JEPE), volume:18, issue: 4, pages:1649–1657,
http://www.jepe-journal.info/journal-content/vol-18-no4

5. M. Ilie, F. Marinescu, G. Ghita, G.S. Tanase, G. Deak, **M.C. Raischi**, 2014. „Assessment of heavy metal in water and sediments of the Danube river", Journal of Environmental Protection and Ecology(JEPE), volume: 15, issue: 3, pages: 825-833,
https://www.researchgate.net/profile/Mihaela_Ilie3

BDI listed publications:

1. **M.C. Raischi**, L. Oprea, G. Deak, S. Zamfir, M. Ilie, N. Raischi, 2016. „Impact of the Lower Danube hydro technical works on sturgeons' migration", International Journal of Environmental Science, volume:1, pages: 213-219, ISSN: 2367-8941
http://www.iaras.org/iaras/journals/caijes/impact-of-the-lower-danube-hydro-technical-works-on-sturgeons-migration

2. M. Ilie, F. Marinescu, A. Anghel, G. Ghita, G. Deak, **M.C. Raischi**, C. Cristinoiu, M. Matei, S. Zamfir, 2016. „Spatial distribution of heavy metal contamination in surface sediments from the Danube River", International Journal of Environmental Science, volume 1, pages: 230-237, ISSN: 2367-8941
http://www.iaras.org/iaras/filedownloads/ijes/2016/008-0036.pdf

National and International presentations:

1. Ștefan A. Zamfir, György Deak, Danalache Tiberius, Lucian Georgescu, **Marius Constantin Raischi**, Alexandru Cristea, Lucian Oprea, Lucian Gheorghe Lumînăroiu, 2019. „Impact of temporary loss of connectivity in the Epurasu branch and its effects on the composition and distribution of ihtiofauna", Conference Paper in AIP Conference Proceedings , DOI: 10.1063/1.5118083
https://www.researchgate.net/publication/334778809

2. G. Deak , **M. C. Raischi**, A. M. Badilita, T. Danalache, A. Cristea, E. Holban, S. Zamfir , M.Boboc M. Matei, B. Uritescu, I. Boaja, D. Stefan, G. Tudor, 2017. „Actual status, pressures and preserving perspectives of sturgeon species from lower Danube River", 8th international Symposium on Sturgeons, September 10th-16th, 2017, Vienna Austria
http://incdpm.ro/production/media/Prezentare_Viena_ISS8.pdf

3. Marius Constantin Raischi, Lucian Oprea, Ștefan Zamfir, Gabriel Badea, Gyorgy Deak. „Comparative study about the usage of new Sturgeon Monitoring Systems in the Lower Danube", CONFERINȚA ȘTIINTIFICĂ A ȘCOLII DOCTORALE "DUNĂREA DE JOS", Universitatea „Dunarea de Jos" din Galati, 2016 Pages: 95, Galati
http://www.cssd-udjg.ugal.ro/index.php/2016/abstracts

4.P. Ionescu, M. V. Radu, R. Szep, **M.C. Raischi**, M. Boboc, 2015. „Characterization of metal flow dynamics along the lower section of Danube river using correlation algorithms", WATER RESOURCES, FOREST, MARINE AND OCEAN ECOSYSTEMS, SGEM 2015, VOL I, Book Series: International Multidisciplinary Scientific GeoConference-SGEM, Pages: 129-135, Conference: 15th International Multidisciplinary Scientific Geoconference, Albena, BULGARIA
https://sgemworld.at/sgemlib/spip.php?article5918

5. Marius Constantin Raischi, Mădălina Georgiana Boboc, Mihaela Ilie, Lucian Oprea, 2015. „Influence of The Hydrochemical Factors on The Sturgeon Behavior in The Lower Danube River", INTERNATIONAL CONFERENCE on Sea and Coastal Development in the frame of Sustainability, MACOODESU, 2015, Pages: 235-241
http://ddni.ro/wps/wp-content/uploads/2017/08/Marine-Costal-Development Sustenability_2015_ABSTRACT.pdf

6. Marius Constantin Raischi, Lucian Oprea, Gyorgy Deak, Alin Badilita, Madalina Boboc. „Comparative study about the usage of new Sturgeon Monitoring Systems in the Lower Danube", CONFERINȚA ȘTIINTIFICĂ A ȘCOLII DOCTORALE "DUNĂREA DE JOS", Universitatea „Dunarea de Jos" din Galati, 2015 Pages: 167, Galati
http://www.cssd-udjg.ugal.ro/index.php/2015/abstracts-2015

Published Patents:

I Patent Nr.: 128559 – *DKTB monitoring station for ichthyofauna and especially sturgeons, by remote sensing with ultrasonic marking under different hydrological conditions*; Authors: Deak Gyorgy, Tănase Bogdan, Bâdiliţă Alin, **Raischi Constantin Marius**, Tănase Georgiana Simona.

II Patent Nr.:129803 – *Mobile monitoring station by remote sensing of ichthyofauna and especially of sturgeons under difficult hydrological conditions*, 2017. Authors: Deak Gyorgy, Raischi Natalia Simona, Bâdiliţă Alin Marius, **Raischi Constantin Marius**, Silion Marius Mădălin, Tudor Marian.

III Patent Nr.: A/00759/26.10.2016- *Technical solutions to protect wetland and population ecosystems from flooding*; Autori: Laslo Lucian Augustin, Matei Monica Silvia, Boboc Mădălina Georgiana , Ciobotaru Nicu, **Raischi Marius Constantin**, Poteraş George, Deak Gyorgy.

Publications:

1. G. Deak, M Ilie, A. Bâdilita, **M.C. Raischi,** et al. 2016. “ Monograph - Monitoring the environmental impact of the works to improve the navigation conditions on the Danube between Calarasi and Braila, km 375 and km 175 ", volume:1-2, Editura UNIVERSITAS, Petrosani, ISBN: 978-973-741-506-6

2. M. Matei, L. Laslo, G. Deak, N. Ciubotaru, M. Boboc, **M. C. Raischi**, et al. 2017. "Good practice guide on mapping and evaluating wetland ecosystems and the services they provide, editura UNIVERSITAS; Petroșani, ISBN: 978-973-741-533-2

Selective Bibliography

[1] The Government of Romania, *HG nr. 80/2011 The National Management Plan of the national portion of the International River Basin of the Danube River,* Bucharest, 2011.

[2] Ministry of Agriculture, Forests and Rural Development, *Ordinul nr. 262/2006 regarding the conservation of sturgeon populations in natural waters and the development of sturgeon aquaculture in Romania,* Bucuresti, 2006.

[3] Ministry of Environment, Waters and Forests, National Administration of Romanian Waters, *The updated national management plan of the portion of the international river basin of the Danube River,* Bucharest: http://www.rowater.ro/SCAR, 2016.

[4] Adams P., Grimes B., Hightower J., Lindley S., Mose M., „Status Review for North American Green Sturgeon, Acipenser medirostris," National Marine Fisheries Service Southwest Fisheries Science Center, Santa Cruz, California, 2002.

[5] Yujun Y., Sun J., Zhang S., „A habitat suitability model for Chinese sturgeon determined using the generalized additive method6," *Journal of Hydrology,* vol. No. 534, p. 11–18, 2016.

[6] Billard R., Lecointre G., „Biology and conservation of sturgeon and paddlefish," *Fish Biology and Fisheries,* vol. 10, p. 355–392, 2001.

[7] Antipa Grigore, „The ichthyological fauna of Romania," 1909.

[8] Jörn Gessner et. al., „ Sturgeon and paddlefish research focuses on low risk species and largely disregards endangered species," *ENDANGERED SPECIES RESEARCH,* vol. 22, p. 95–97, 2013.

[9] Catarci Camillo, „World markets and industry of selected commercially-exploited aquatic species," Fisheries and Aquaculture Department Of Food and Agriculture Organization of the United Nations, Rome, 2004.

[10] Marieta Costache, Andreea Dudu, Sergiu Emil Georgescu, „Low Danube Sturgeon Identification Using DNA Markers," în *Analysis of Genetic Variation in Animals*, Rijeka, Croatia, INTECH, 2012, pp. 243-269.

[11] Fish Base, [Interactiv]. Available: http://www.fishbase.org/identification/SpeciesList.php?genus=Acipenser. [Accesat 22 June 2017].

[12] Vasil'eva Ekaterina, „Morphological and Morphometric Characters in Sturgeon Taxonomy and Phylogeny," vol. 29, pp. 51-61, 2009.

[13] M. S. University, „Introduction to Sturgeon Taxonomy," [Interactiv]. Available: http://www.glsturgeon.fw.msu.edu. [Accesat 10 June 2017].

[14] Alina-Florina Nicolae, Puiu-Lucian Georgescu, György Deák, Alin Badilita, Marian Tudor, „Preliminary analysis of the sturgeon' swimming capacity above the bottom sill through numerical simulation. Case study - Bala branch," *Environmental Engineering and Management Journal* , vol. 15, pp. 1075-1080 , 2016.

[15] Bâdiliță Alin et al., „Contributions to understanding the fall migration of beluga sturgeon (*Huso huso*) on the Lower Danube River, Romania," *International Journal of the Bioflux Society, AACL Bioflux,* vol. 6, nr. 4, pp. 281-296, 2013.

[16] Joanne S. Beukers, Geoffrey P. Jones, Raymond M. Buckley, „Use of implant microtags for studies on populations of small reef fish," *MARINE ECOLOGY PROGRESS SERIES* , vol. 125, pp. 61-66, 1995.

[17] William T.Slak, Mark S. Peterson, Douglas G. Clarke , „Summary of Gulf Sturgeon monitoring activities on Ship Island,” US Fish and Wild Services, Mississippi, 2012-2013.

[18] University of Southern Mississippi, „Gulf Costal Research Laboratory,” [Interactiv]. Available: http://gcrl.usm.edu/public/fish/gulf.sturgeon.php. [Accesat 7 June 2017].

[19] Marius Constantin Raischi1, Lucian Oprea, Gyorgy Deak ,Alin Badilita, Marian Tudor, „COMPARATIVE STUDY ON THE USE OF NEW STURGEON MIGRATION MONITORING SYSTEMS ON THE LOWER DANUBE,” *Environmental Engineering and Management Jornal,* vol. 15, pp. 1081-1085, 2014.

[20] INTERNATIONAL HYDROGRAPHIC ORGANIZATION, *IHO STANDARDS FOR HYDROGRAPHIC SURVEYS,* Monaco: International Hydrographic Bureau, 2008.

[21] J.P. Porcher F. Travade, „Fishways : Biological basis, limits and legal considerations,” *Bull. Fr. Pêche Piscic.,* vol. 364, pp. 9-20, 2002.

[22] Cristina MUSCALU, Radu MUSCALU, Biology and growth of the sturgeons, Cluj-Napoca: Bioflux, 2009.

[23] The IUCN Red List of Threatened Species, „Acipenser guldentaedti,” [Interactiv]. Available: http://www.iucnredlist.org/details/summary/232/0. [Accesat 16 may 2017].

[24] The Iucn Red List of Threatened Species, „Acipenser stellatus,” [Interactiv]. Available: http://www.iucnredlist.org/details/229/0. [Accesat 20 May 2017].

[25] Fish Base, „Acipenser ruthenus, Linnaeus, 1758,” [Interactiv]. Available: http://www.fishbase.org/summary/4604. [Accesat 22 May 2017].

[26] The IUCN red list of threatened species, „*Huso huso*,” UCN Global Species Programme Red List Unit, [Interactiv]. Available: http://www.iucnredlist.org/details/10269/0. [Accesat 29 martie 2018].

[27] Convention on International Trade in Endangered Species of Wild Fauna and Flora, „Barbel Sturgeon,” [Interactiv]. Available: www.cites.org/eng/gallery/species/fish/acipenser_nudiventris.html. [Accesat 21 July 2019].

[28] The IUCN Red List of Threatened Species, „Acipenser nudiventris,” [Interactiv]. Available: http://www.iucnredlist.org/details/225/0. [Accesat 22 May 2017].

[29] VEMCO, „Study behaviour and migration of animals in lakes, rivers and oceans,” VEMCO, [Interactiv]. Available: https://vemco.com/products/. [Accesat 07 July 2017].

[30] Steven T. Kessel, Nigel E. Hussey, „Tonic immobility as an anaesthetic for elasmobranchs during surgical implantation procedures,” *Canadian Journal of Fisheries and Aquatic Sciences,* vol. 72, pp. 1287-1291, 2015.

[31] A. Hussain, H. A. Shakir, S. Ali* and J. I. Qazi, „GROWTH COEFFICIENT AND FECUNDITY OF CHITALA CHITALA (OSTEOGLOSSIFORMES: NOTOPTERIDAE) FROM THE RIVER RAVI, PAKISTAN,” *The Journal of Animal & Plant Sciences,* vol. 25, pp. 401-405, 2015.

[32] Pauly Daniel, „ On the interrelationships between natural mortality, growth parameters, and mean environmental temperature in 175 fish stocks,” *J. du Conseil,* vol. 39 , pp. 175-192, 1980.

[33] Tiago Magalhães da Silva FREITAS et al., „Length-weight relationship in ten fish species from the Nhamundá River, the Amazon Basin, Brazil,” *Journal Acta*

Amazonica, vol. 47, pp. On-line version ISSN 1809-4392, 2017.

[34] Ralf Riedel , Lucille M. Caskey & Stuart H. Hurlbert, „Length-weight relations and growth rates of dominant fishes of the Salton Sea: implications for predation by fish-eating birds," *Lake and Reservoir Management,* vol. 23, pp. 528-535, 2007.

[35] Gheorghe Manea, Sturionii Biologie, Sturionicultură și Amenajări Sturionicole, Bucuresti: Editura Ceres, 1980.

[36] Reinartz, R., „Sturgeons in the Danube River. Biology, status, conservation," International Association for Danube Research (IAD), Bayern, 2002.

[37] Wikipedia Enciclopedie liberă, „Dunărea," [Interactiv]. Available: https://ro.wikipedia.org/wiki/Dun%C4%83rea. [Accesat 18 Martie 2018].

[38] Ministrul Mediului și Gospodăririi Apelor, *ORDIN NR. 161 pentru aprobarea Normativului privind clasificarea calitatii apelor de suprafata in vederea stabilirii starii ecologice a corpurilor de apa,* București, 2006.

[39] M. Niculescu-Duvăz, Migraţia peştilor, 1958.

[40] The IUCN Red List of Threatened Species, „Acipenser ruthenus," [Interactiv]. Available: http://www.iucnredlist.org/details/227/0. [Accesat 18 May 2017].