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# Review & Completion of the Feasibility Study for the Improvement of Navigation along the Joint Danube Romanian - Bulgarian Sector & Complementary Studies "FASTDANUBE"

**Consultancy Contract 965 HRO / July 2018**

## Preliminary Migratory Fish Habitat Assessment

*"Preliminary Migratory Fish Habitat Assessment - field work results & Initial assessment of proposed options to improve navigation"*

*Compiled by Stefan Hont, DDNI Tulcea*
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## Summary

Demonstration of functional spawning sites for sturgeons involves: (i) using acoustic telemetry to track movements of adults entering the river for spawning, (ii) describing the nature of bottom substrate using either the simple "Kynard probe" (Kynard 2002), Van Veen grab sampler or up-to-date side scanners with adequate substrate recognition software, (iii) collecting eggs using artificial traps / mattresses (Jackson 2013; Poytress 2017) set at the potential spawning sites, and (iv) capturing larvae by using stationary bottom drift nets. As these activities have strong time and site related constraints, describing and demonstrating the location of functional spawning sites on such long reaches of the Lower Danube River (LDR) like for the FASTDANUBE project is a multi-year task, even if field work would be divided among many coordinated teams. Since spawning of sturgeons is known to be guided by a strong homing behaviour (Greene 2009; Kieffer & Kynard 2012a, 2012b), the possibility of recreating spawning substrates / sites in the relocated fair way for navigation in the framework of the FASTDANUBE project is strongly dependent on knowledge / gathering data about the location and functioning of the existing spawning site in this very long reach of the LDR.

This preliminary habitat assessment of anadromous sturgeon species describes potential sturgeon habitats located within the Fast Danube project area, that may be affected by the proposed works to improve navigation conditions between Iron Gate II dam (rkm 864) and Călărași (rkm 375). Potential sturgeon spawning and wintering habitats; and young of the year (YOY) feeding and nursery habitats was identified by finding similarities between studied habitats at rkm 100, rkm 310 (spawning habitats), rkm 123 (YOY feeding habitat) and the wintering pits/holes and vertical clay banks (spawning habitats) on the Borcea branch.

In case of Black Sea Herring / Shad (*Alosa immaculata* Bennet 1835), whose migration begins in the early spring, and the end in June - July (Navodaru 1998) their presence within and between Critical Points (CPs) was established by using a 100m long, 2m high and 20 mm mesh size drift net. The Pontic shad (*Alosa immaculata* Bennet, 1835) and Azov Shad (*Alosa tanaica* Grimm, 1901) are species that spawn in the water column, the eggs are pelagic, and larvae drift passively to the Black Sea (Aprahamian 2003; Navodaru 1998). Due to this spawning behavior the Pontic shad and Azov Shad are less affected than sturgeon species that spawn on hard substrate which will be more affected by planned works on changing the navigation channel in order to improve the navigation. The survey of Pontic shad and Azov Shad was limited to identify their presence or absence in the area. Although shad species are very sensitive (shad died soon after is captured) telemetry studies may be attempted to try to collect more data about shad migration behavior.

## Introduction

Anadromous migratory fishes were and still are the most valuable fishery resource of the Danube River that spends their life cycles partially in fresh water and partially in salt water. Most important anadromous species spawning in the Danube River are the shads (Pontic Shad (*Alosa immaculata*), Azov Shad (*Alosa tanaica*)) and anadromous sturgeons (Beluga Sturgeon (*Huso huso*), Russian Sturgeon (*Acipenser gueldenstaedti*) and Stellate Sturgeon (*Acipenser stellatus*). The spawning area of these species has been reduced by the construction of hydropower and navigation systems at Iron Gates I (1971) and Iron Gates II (1984) (Năvodaru 1998). The design of these dams has not included any fish passage facility. Despite damming at Iron Gates, sturgeon populations survived in the LDR due to still functioning essential habitats for wintering, spawning and nursing of young of the year, located downstream of the dams. The hydrological regime of the Danube remained the same downstream the Iron Gate II dam (ex: at rkm71). The mean timing of spring water level peak before (1935 - 1965) and after damming (1974 - 2016) has remained unchanged occurred around the date of 2 May, enabling spawning of Beluga Sturgeons on hard substrates cleaned of fine sediments by high water discharge in the spring season (Suciu 2005). Detailed knowledge of the choice and behavior of sturgeons in the wild on their spawning habitats in rivers is still poor / missing. A hint of this was provided by a large scale experiment conducted at the Conte Lab of the United States Geological Society (USGS) in Turner's Falls (Kynard et al. 2012).

Due to distinct features of their life cycle the three anadromous species of the LDR spawn in different substrate, temperature, water depth, turbidity, and flow conditions. It is known that most sturgeon lay eggs in flowing water ranging from 46 - 76 cm/s (Greene 2009, Kieffer & Kynard 2012a).

Substrate is a key habitat parameter for sturgeons spawning in the LDR, as hard bottom is required for successful egg attachment and incubation; and protects larvae from predators. Potential spawning substrates include cobble, small rubble and gravel, hard clay, and even limestone substrate. So far, we succeeded only to demonstrate the location and functioning of spawning habitats for Beluga and Sterlet (*Acipenser ruthenus*) Sturgeons at Danube Km 311 (in May 2004) and D Km 100.5 (in May 2008). Substrate and water flow conditions above the bottom at D Km 311, the "Red Rock" site, has been described by our early work under the guidance of Professor Boyd Kynard / USGS, in May 1999 (Kynard 2002). Successfully capturing larvae of these two species at this first site in May 2004 (Suciu 2017) was conditioned by the progress in understanding that the timing of spawning on hard substrate of Beluga and Sterlet Sturgeons happens in the narrow time window after the very peak of water discharge / water level at that site; and can only be estimated retroactively by monitoring water level (Suciu 2005). Very little is known so far about the characteristics of spawning sites in the LDR of the other two anadromous sturgeon species spawning in the LDR, Russian and Stellate Sturgeon.

Indirect information about the existence of functional spawning sites for Stellate Sturgeon was obtained while monitoring migration of this species on the Borcea and Bala branches, in June 2011, as part of the ROMOMED project (www.afdj.ro/en/content/romomed). Since the bottom of these two large branches of the LDR is dominated by sand we hypothesised that spent Stellate Sturgeon females, captured and tagged post-spawning, during the last week of June 2011, were spawning either on hard clay banks, quite abundant on the these branches, or on sites were the river has washed the sand on the bottom and reached / revealed the limestone bedrock, forming stalactite-like structures suitable for egg attachment and protection of early life stages from predators (Suciu 2012).

## Conservation Actions

All three anadromous migratory sturgeon species Beluga Sturgeon (*Huso huso*), Stellate Sturgeon (*A. stellatus*) and Russian Sturgeon (*A. gueldenstaedti*) are listed on CITES Appendix II since 1998 (Gesner 2010; Qiwei 2010). In 2006 Romania declared a 10-year moratorium for all sturgeons' species example followed by other three countries from LDR basin (Ukraine, Bulgaria, and Serbia). In 2016 the moratorium was extended for five more years until 2021. After 2006 Romania started a restocking program of the Danube River releasing up to 500 000 young of the year (over 15 cm long) in Danube River form all three anadromous migratory sturgeon species and one resident sturgeon species between 2006 - 2015 (Rosten 2012; Cristea 2016).

Both Alosa species are listed in the Habitats Directive Annex II and V, the conservations status is unfavorable inadequate in Danube River and Black Sea, largely influenced by the status of Danube population. In Romania the status is unfavourable inadequate in in Danube River and Black Sea, while Bulgaria evaluates the status of Danube population is favorable (Report 1).

The Romania National Agency for Fishing and Aquaculture (NAFA) allow Black Sea Herring / Pontic Shad *(Alosa immaculata*) and Azov Shad (*Alosa tanaica*) fishing on different sectors of the river with periods of fishing restriction.

# LITERATURE REVIEW

## Examples of sturgeon habitats identified in previous projects in the rkm 350 – rkm 100 Danube River sector

Worldwide survival and recovery of depleted stocks of sturgeon populations is recognized to be conditioned by the existence and functionality of essential habitats for wintering, spawning and nursery in the home range Rivers of the different species. Due to lack of proper funding and prioritization by both fisheries and environmental authorities, essential habitats for sturgeons in the LDR are poorly known.

Some of the “spawning sites of beluga (*Huso huso*) located along the Bulgarian-Romanian Danube River” have been only preliminarily located by Vasillev (2003). The The Danube Delta Nationa Institute DDNI Tulcea, Sturgeon Research Group team (SRG) has focused its sturgeon habitat work only in the very lower reach of the LDR (downstream rkm 350).

Examples of the sturgeon habitats identified in the very lower reach of the LDR are described in Table 1. This information has been used by the field team to help to identify potential sturgeon habitat within the project area.

*Table 1: Examples of identified sturgeon habitats (rkm 350 - rkm 100) by SRG of DDNI that will be used as an example to identify new habitats between Iron Gate II Dam and rkm 375*

| Species | **Habitat type** | **Location [rkm]** | **Summary of key findings of surveys** |
|---|---|---|---|
| ***A. ruthenus*** | spawning site | Danube km 310 | Capture of larvae in May 2004 and 2007; bahymetric and substrate survey; identification of species with molecular markers;<br>Habitat substrate with rocks / boulder |
| | spawning site | Danube km 100 | Capture of larva in May 2009; bahymetric and substrate survey; identification of species with molecular markers;<br>Habitat substrate with rocks / boulder |
| | juvenile feeding ground | Borcea branch km 61-62 | Capture of YOY in July 2011 |
| | juvenile feeding ground | Caleia branch km 0 - 1 | Capture of YOY in July 2011 together with YOY of *A. stellatus* |
| | juvenile feeding ground | Danube km 123 | Capture / monitoring abundance of YOY during 2000 - 2012;<br>every second year survey of bottom fauna combined with stomach content of YOY |
| ***A. güldenstädtii*** | juvenile feeding ground | Danube km123 (850 m) | Capture / monitoring abundance of YOY during 2000 - 2012;<br>every second year survey of bottom fauna combined with stomach content of YOY |
| ***A. stellatus*** | spawning site | Borcea branch km 56 - 57 | Captured males loosing milt and spent females on 24 June 2011. There are many hard clay. |
| | juvenile feeding ground | Borcea branch km 61-62 | Capture of YOY in July 2011 |
| | | Caleia km 0 - 1 | Capture of YOY in July 2011 |
| | | Danube km123 (850 m) | Capture / monitoring abundance of YOY during 2000 - 2012<br>Every second year survey of bottom fauna combined with stomach content of YOY |
| ***H. huso*** | wintering site | Bala km 7,7 | acoustic telemetry and multibeam bathymetric survey; Beluga male recorded (by fixed submerged receiver) there for 4 days during 9 - 14 Dec. 2011 at a depth of 20.8 - 21.1 m |
| | wintering site | Bala branch km 5 - 6 | acoustic telemetry and multibeam bathymetric survey; Beluga male recorded (by mobile receiver) there for 29 days during 16 Dec.2011 - 14 Jan. 2012 |

| | | | |
|---|---|---|---|
| | | | at a depth of 16 - 19 m |
| | wintering site | Borcea branch km 49 | Acoustic telemetry and multibeam bathymetric survey; Beluga male recorded (by drifting submerged receiver) on 18 March. 2012 at a depth of 27 m |
| | spawning site | Danube km 100 | Capture of larva in May 2008; bathymetric and substrate survey; identification of species with molecular markers; Habitat substrate with rocks / boulder and limestone |
| | | Danube km 310 | Capture of larva in May 2004; bathymetric and substrate survey; identification of species with molecular markers; Habitat substrate with rocks / boulder and gravel (Figure 3) |
| | juvenile feeding ground | Danube km 123 | Capture / monitoring abundance of YOY during 2000 - 2012; every second year survey of bottom fauna combined with stomach content of YOY |

## Example of identified wintering habitats

Deep low-velocity microhabitats provide winter refuge sites for adult sturgeons. These conditions allow for maximal resting-position energy conservation. Therefore, it is evidence that both depth and bottom velocity are fundamental habitat conditions sought by anadromous sturgeons entering the LDR in autumn, to spawn in spring, further upstream.

Wintering sites / holes for sturgeons on the Sfantu Gheorghe branch (R Km 67) were located by the SRG in 1999 using acoustic telemetry. Use of wintering holes on the Borcea (Km 49) and Bala (Km 7.5) branches by Beluga Sturgeons carrying acoustic transmitters was also demonstrated during the winter 2011 – 2012 (Figure 1 & 2).

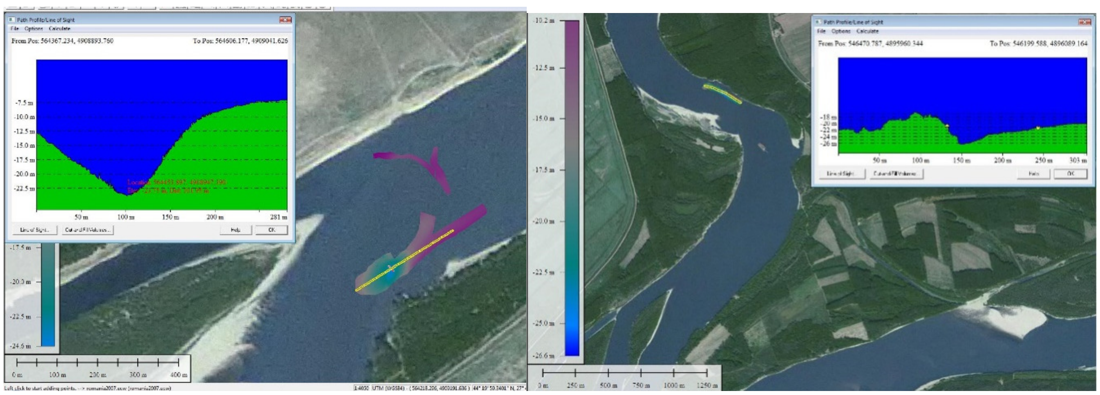

*Figure 1: Wintering holes for sturgeons on the Borcea branch, Km 49 ( depth = 12.5m) (left), and on Bala branch, Km 7.5 (depth = 8m) (right)*

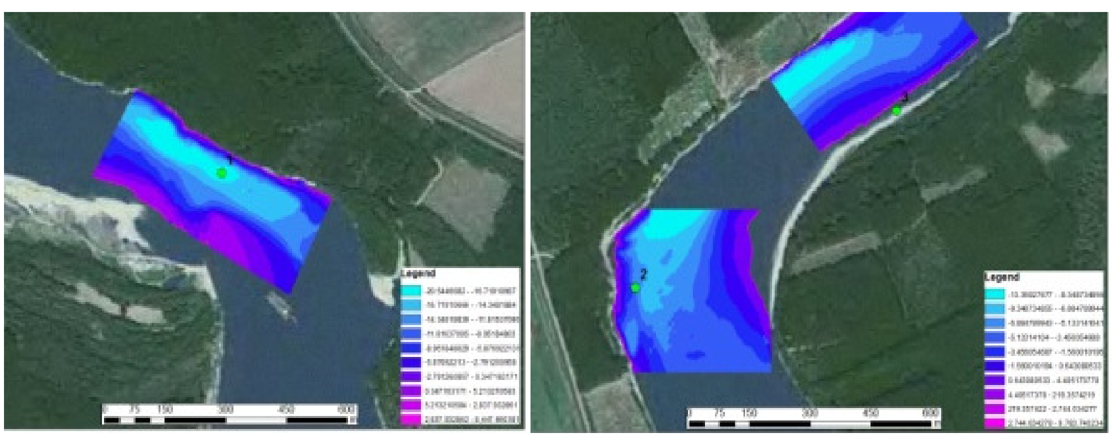

*Figure 2: Wintering habitat Bala branch Km 7,7 (left) and Bala branch Km 5 – 6 (right)*

## Example of identified spawning habitats before FASTDanube project

Existence of functional sturgeon spawning sites and environmental conditions in their home range rivers (water depth, discharge, temperature, turbidity, velocity) are crucial for the survival of sturgeons. Substrate is a key habitat parameter for sturgeons spawning in the LDR, as hard bottom is required for successful egg attachment and incubation; it also protects larvae from predators. Potential spawning substrates include cobble, small rubble and gravel, hard clay, and even limestone substrate (Table 1).

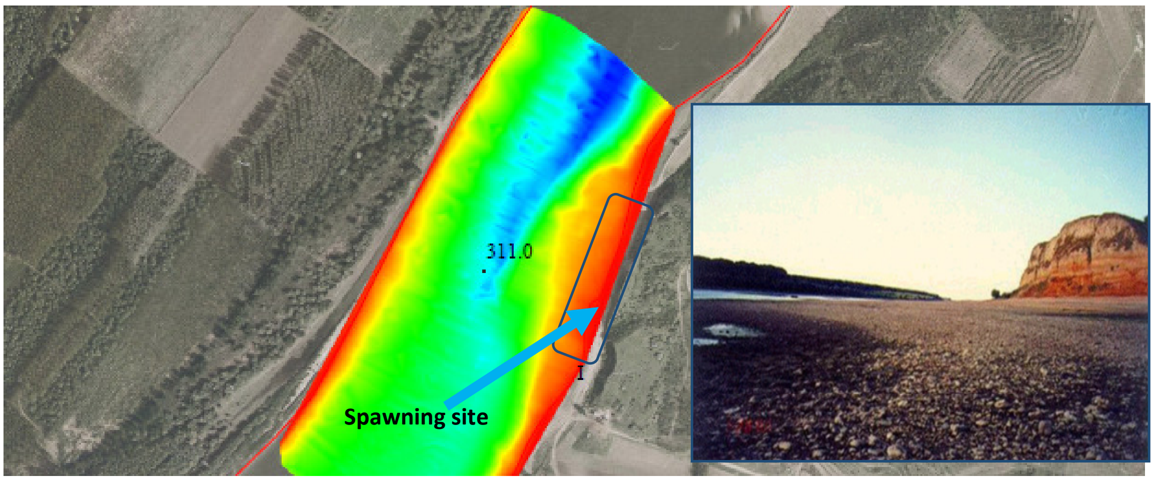


*Figure 3: 3D bathymetric map of the spawning site Red Rock / Rasova / D Km 311, with an insert view of the ground at very low water level in July 2000*

Substrate with rocks / boulder and gravel located at rkm 311, the "Red Rock" site poeoved to be a Belga and Sterlet Sturgeon spawning habitat (Figure 3). Successfully capturing larvae of Beluga and Sterlet Sturgeons species at the red Rock site in May 2004 was conditioned by the progress in understanding that the timing of spawning on hard substrate of Beluga and Sterlet Sturgeons happens in the narrow time window after the very peak of water discharge / water level at that site, and can only be estimated retroactively by monitoring water level.

## Example of identified feeding habitats of young of the year (YOY)

The identification of sturgeon feeding habitats is a particularly important activity given that sturgeon YOY are the most vulnerable to the loss or degradation of these areas, mainly caused by the entropic factor. Identification of sturgeon feeding habitats can be achieved through a qualitative assessment of benthic fauna in the potential nursery sites (Figure 4) and by capturing YOY using drifting nets (Figure 5).

*Figure 4: Samples of cleaned substrate extracted from the feeding habitat located at rkm 123 in June 2018. Small gravel (left); small worms and Freshwater bivalves (right)*


*Figure 5: YOY Beluga sturgeon captured in 2017 at rkm 123*

## The Pontic shad (*Alosa immaculata* Bennet, 1835)

The Pontic shad (*Alosa immaculata*), is the largest species of the family Clupeidae in the Black Sea and it is also referred to as the Black Sea shad, which is a species of clupeid fish in the genus *Alosa*, native to the Black Sea and Sea of Azov basins. It is an anadromous migratory fish species that currently migrates upstream in the Black Sea tributary rivers to spawn.

Shad migration begins in the early spring (February / March), when Danube water temperature reaches 3-7.5 $^0$C. Migration reaches a peak in April / May when water temperatures reach between 9-17 $^0$C, and ends in June - July when water temperatures reach between 22- 26 $^0$C.

Spawning takes place in fresh water during the night. The males and females, half submerged and alongside each other swim in a circular motion violently thrashing the surface of the water with their caudal fin, releasing sperm and eggs into the water column. (Aprahamian 2003). According to Navodaru (1998)

Spawning takes place between rkm180 and 500. Eggs are pelagic and larvae drift passively to the Black Sea. The larvae can be sampled using a single conical shaped net (Bongo net), of 0.5

m in diameter, 1.35 m length, 0.4 m for cod end length with 0.5 mm bar mesh size (Navodaru 2001). For adults fishing gill nets can be used of 50 – 100 m.

Previously Pontic shad the migrations reached far upstream in Danube River up to rkm 1,600 to Mohacs Hungary, but now dams are restricting the migrations (Freyhof 2008). The Pontic Shad is spawning between river kilometers 180 and 500 (Navodaru 2001) but there are reported catches of Pontic Shad in the close vicinity of Iron Gate II dam; we successfully captured Pontic Shad specimens at rkm 626 (Figure 26) . For Romania, Ukraine and Bulgaria, the stock of Pontic shad is an important fishery. (Figure 6).


*Figure 6: Danube Shad captured accidentally during the YOY fishing at rkm 123 in 2017*

## Azov Shad (*Alosa tanaica* Grimm, 1901)

Azov Shad (*Alosa tanaica)* is an anadromous species that lives in the Black Sea from where adults (1-2 years old) ascend rivers, migrating a short distance upstream to spawn. The Azov Shad migrates from sea to mouth and lower reaches of large rivers, spawns in fresh or slightly brackish water, usually close to shore, in upper 2-4 m, in almost still water bodies. Azov Shad adults appear along coast in late January-March and enter rivers when temperature reaches about 10°C, in late April-May.

Spawning starts when water temperature reaches approximately 15°C or above, in May-June. Eggs are bathypelagic or sink to bottom. Spent fish migrate to estuaries and coastal lagoons or to sea near river mouths to feed. In autumn, they move to sea to overwinter. Juveniles migrate to sea or estuaries during first summer, remaining there until they mature. At sea, the Avov Shad feeds on a wide variety of zooplankton (crustaceans), insect larvae and small fish (Freyhof 2008b, Oţel 2007).

# FIELD SURVEY

## Introduction

Spawning of sturgeons is known to be guided by a strong homing behaviour, the possibility of recreating spawning substrates / sites in the relocated fair way for navigation in the framework of the FAST Danube project is strongly dependent on knowledge / gathering data about the location and functioning of the existing spawning site in this very long reach of the LDR.

This preliminary habitat assessment of migratory fish species will identify potential sturgeon habitats located in the Fast Danube project CPs or between CPs that may be affected by the navigation works to improve navigation conditions between Iron Gate II dam (rkm 864) and Călărași (rkm 375). The identification of the potential sturgeon adult spawning and wintering habitats and YOY feeding habitats was accomplished by finding similarities between habitats (described above & Table 1) studied before and rkm 100 and rkm 310 (spawning habitats), rkm 123 (YOY feeding habitat) and the wintering pits and vertical banks (spawning habitats) form Borcea branch.

## Methodology

### Desk Study

Before fieldwork trip, in order to enable focused survey efforts, bathymetry data was analyzed using Global Mapper software in order to identify the potential sturgeons wintering pits used by sturgeons as wintering habitats (Figure 7) and vertical clay banks which provide potential spawning habitats for Stellate Sturgeons.

Sediment data was also analyzed to identify locations with gravel substrate as this provides potential Beluga Sturgeon spawning habitats (Figure 8).

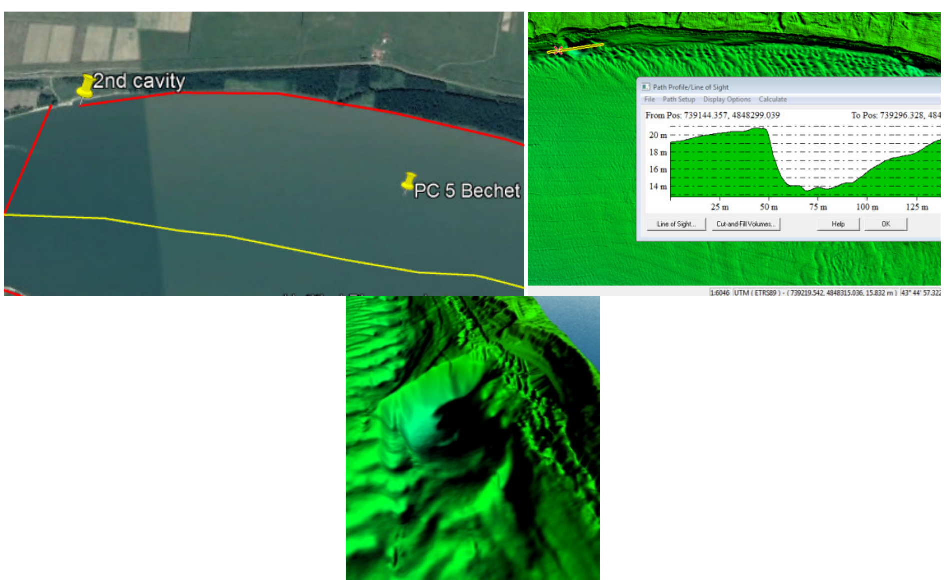


*Figure 7: Potential wintering pit found using bathymetry data at CP 5 / Bechet*

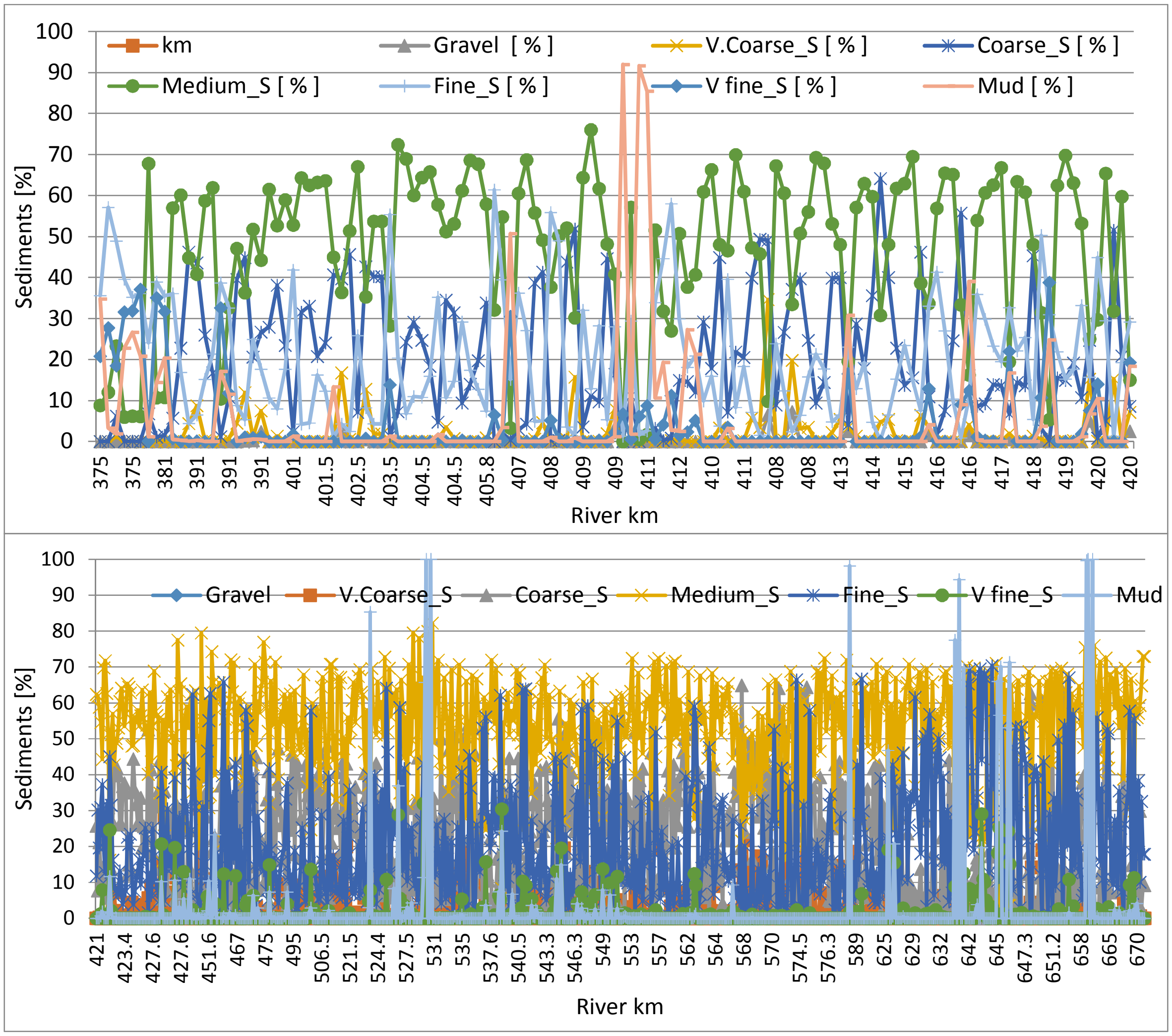


*Figure 8: Sediments between river km 375 and river km 668*

## Field work

The transport of personal, equipment and the boat in the field was done using a VW Transporter along the Danube River bank between rkm 864 and rkm 375. Transportation on the water was done using an aluminum Linder Sportsman boat equipped with and 10 HP Engine. The boat is also equipped with a special manufactured platform to install the Portable Flowmeter used for measurement of water velocities in the potential wintering habitats.

During this assignment fishing permits have been obtained from Romanian Fishery Administrations, issued by National Agency for Fishing and Aquaculture (NAFA) Bucharest, for capture migratory species using a 20 mm mesh size nets (Figure 9).


*Figure 9:  Humminbird sonar (left), GPS Garmin (center) fishing using a drift net (right)*

Sonar Humminbird Helix 5 SI GPS and two GPS Garmin GPSMAP (Figure 9) were used to investigate the wintering pits.

The substrate in the potential sturgeon spawning habitats was sampled using a Kynard probe and a Van Veen grab sampler (Figure 10).

*Figure 10: Van Veen grab and sieve for substrate samples (left & middle) Kynard probe (right)*

For the measurement of water velocities in the wintering pits (close to the river bottom / 0-50 cm) a lead weight a Vinch and Flowmeter FLO_MATE Model 2000 was used, this was installed on the Linder Sportsman boat on a special manufactured platform (Figure 11).


*Figure 11: Portable Flowmeter FLO_MATE Model 2000 used for measurement of water velocities close to the bottom of the river*

### *Field work limitations*

The required survey activities have strong time and site related constraints, describing and demonstrating the location of functional spawning sites on such long reaches of the LDR like for the FAST Danube project is a multi-year task, even if field work would be divided among many coordinated teams and accordingly the discussions that took place at the Workshop from 17 may 2018 the work was divided in three phases:

- Phase I - Belene, Bechet, Corabia si Popina
- Phase II – Vardim, Iantra, Batin si Kosui
- Phase III – Garla Mare, Salcia, Bogdan Secian si Dobrina

## Survey results

Two fieldwork trips have been undertaken with the aim being to identify similarities between the confirmed sturgeon habitats in the very Lower reaches of the LDR between rkm 310 and rkm 100 (described in Table 1).

- **Field trip 1 -** The first field work trip was undertaken between 26 October – 2 November 2017. This trip covered all CPs other than CP 3 and CP 4 which could not be surveyed due to adverse weather conditions. This field work focused on identifying potential habitats along the Romanian river bank based and made us of the bathymetry data analyzed during the office work to focus the survey effort.

- **Field trip 2** - The second fieldwork trip was undertaken between 01st - 05th July 2018. This trip focused on the Bulgarian river bank at CP 5, CP 6 and CP 7 and These CPs were selected as they had been identified by the project engineers as the most likely sites to require physical intervention beyond dredging.

These two field work trips give more attention to sturgeon habitats because the Pontic and Azov Shad are species that spawn in the water column. This spawning behavior results in the Pontic and Azov Shad being less affected than sturgeon species that spawn on hard substrate and thus have greater potential to be affected by works to improve the navigable conditions.

The survey of Pontic shad and Azov Shad was limited to identify their presence or absence in the area. Although shad species are very sensitive (shad died soon after is captured) telemetry studies may be attempted to try to collect more data about shad migration behavior.

## Critical Point 1 Gârla Mare – Romanian sector

During field trip 1, pebble / gravel (Figure 12) was identified at rkm 840 just upstream of CP 1, Garla Mare and a clay vertical bank was identified at rkm 844.5 on the Romanian bank (left), approximately 5 km upstream of CP 1, Garla Mare. Vertical bank GPS location is 44°12.315' / N 22°42.833' E.


*Figure 12: River banks with gravel potential spawning habitats of Beluga Sturgeons (CP1)*

The timing of spawning on hard substrate of Beluga and Sterlet Sturgeons happens in the narrow time window after the very peak of water discharge / water level at that site; and can only be estimated retroactively by monitoring water level. So far are many gaps on the characteristics of spawning sites in the LDR of the other two anadromous sturgeon species spawning in the LDR (Russian and Stellate Sturgeon), but is possible that Stellate Sturgeon to spawn either on hard clay banks which is quite abundant in LDR (Figure 13). It is also possible for this specie to use sites were the river has washed away the sand on the bottom to reveal the limestone bedrock, forming stalactite-like structures suitable for egg attachment and protection of early life stages from predators.


*Figure 13: Vertical river clay banks potential spawning habitats used by Stellate Sturgeons near to CP 1*

### Critical Point 2 Salcia – Romanian sector

In the CP 2 sector on the Romanian bank (left) a large area with gravel on the shore, and vertical banks with small holes in it were identified. These provide suitable habitat for the Stellate Sturgeons spawning habitats (Figure 14).


*Figure 14: CP 2, Romanian Danube River banks with gravel and vertical clay banks potential spawning habitats of Beluga and Stellate Sturgeon*

The vertical clay banks in this area are noted to be similar to the vertical banks confirmed as being used by Stellate Sturgeon for spawning on the Brorcea branch. On the Bulgarian side (right bank) the banks are higher ≈ 5-10 m high (Figure 15).


*Figure 15: Romanian river bank (left photo) and Bulgarian River bank (right photo)*

### Critical Point 5 Bechet – Romanian sector

A potential sturgeon wintering site was located in the CP 5, lose to the right river bank GPS location of the wintering hole/pit 43°44.953' / N 23°58.264' E. This hole was found to be 8 meters deep. The potential wintering pit/hole has formed into a small golf area (Figure 16).

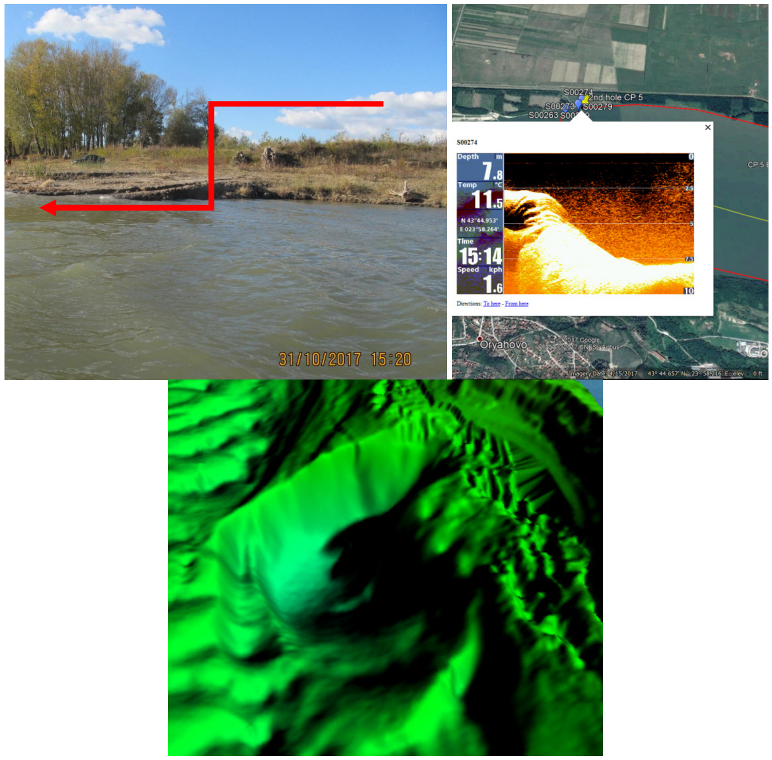


*Figure 16: The potential wintering pit /hole located close to the right river bank downstream the Bechet harbor / CP 5*

Water velocities measurements in the potential wintering site are provided in Table 2 below. The water velocities measured in the potential wintering habitat are under the critical burst swimming speed (1.4 – 1.6 m/s) measured in sturgeon species (Parsley 2008; Adams 2003).

This potential wintering habitat may be studied during the future project of monitoring the environmental impact on migratory species in the frame of the project for improving navigation condition on Danube River between Iron Gate II Dam and rkm375. The wintering habitat can be studied during the winter time in detail to see whether or not is used by sturgeon species, using acoustic telemetry, direct survey with DIDSON camera or other equipment that can prove sturgeon presence in the area.

*Table 2: Water velocities measurements in the potential wintering site located in the CP 5*

| Crt. No. | habitat type | Coordinates of the measurement location | 20 cm from the bottom [m/s] | 50 cm from the bottom [m/s] | 100 cm from the bottom [m/s] | 100 cm from the surface [m/s] | 200 cm from the surface [m/s] | 400 cm from the surface [m/s] | 10 cm from the surface [m/s] |
|---|---|---|---|---|---|---|---|---|---|
| 1 | wintering | N:430 44.946` E:230 58.265` | 0.24 | 0.24 | 0.33 | 0.87 | 0.9 | 0.78 | 0.9 |
| 2 | | | 0.19 | 0.22 | 0.38 | 0.93 | 0.86 | 0.76 | 0.86 |
| 3 | | | | 0.25 | 0.39 | 0.93 | 0.84 | 0.75 | 0.86 |
| 4 | | | | | 0.48 | | | 0.78 | 0.83 |

On the Bulgarian Danube River bank potential sturgeon spawning habitat was identified. This habitat begins at N:43$^0$ 43.851` E:24$^0$ 00.151`and ends at: N:43$^0$ 43.747` E:24$^0$ 00.527` (Figure 17). The bottom samples extracted with the Van Veen grab sampler reveal gravel substrate (Figure 17).

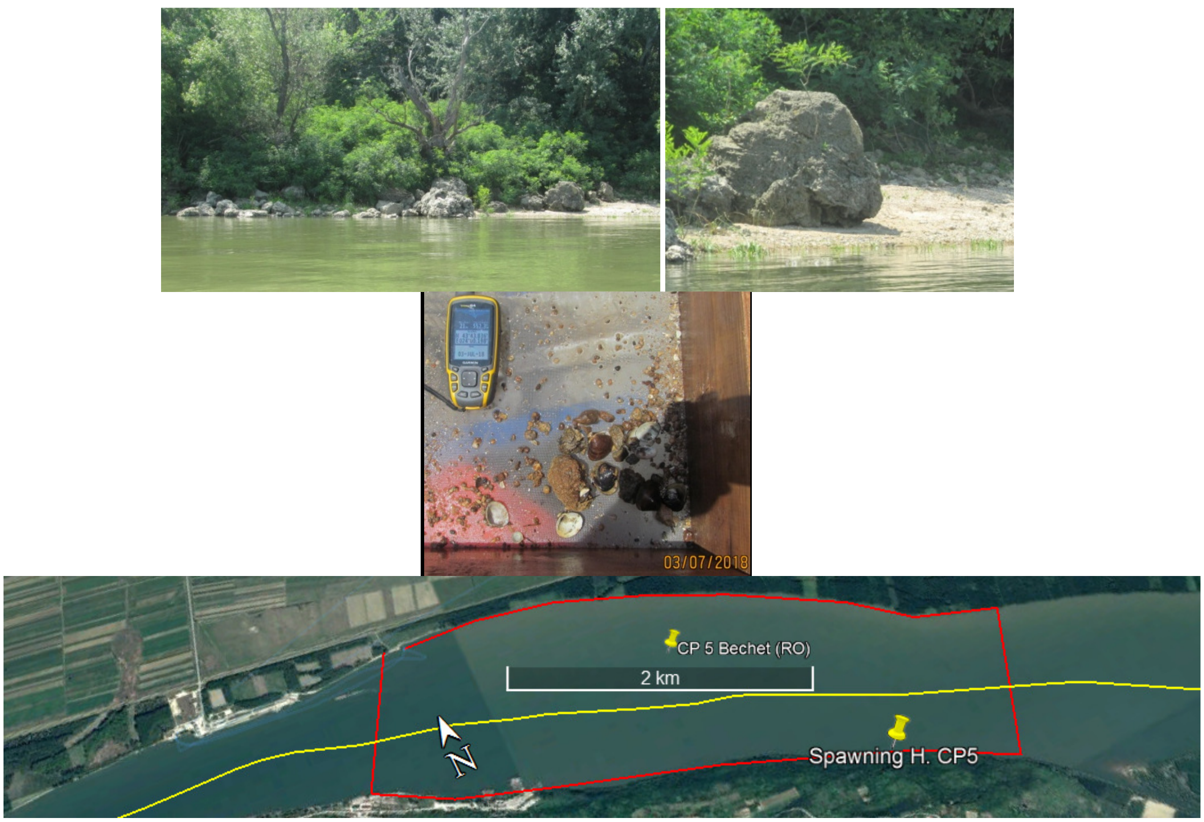


*Figure 17: Potential spawning habitat located close to Bulgarian Danube River bank*

During Field trip 2 the fishing net was launched approximately 2 km downstream the CP5 Danube rkm671 close to Romanian bank at N: 43$^0$ 43.616` E: 24$^0$ 02.725`and was raised at N: 43$^0$ 43.297` E: 24$^0$ 03.841`. The water depth in the fishing location: 8.2 m – 2. 7 m. No fish was captured.

The drift net was launched again at rkm 661 (approximately 12 km downstream of CP5) downstream the island formed by the Danube River close to Romanian river bank. The net was launched at N: $43^0$ 41.763` E: $24^0$ 08.692` (Figure 18). Water depth in the fishing location was between 6.1 m and 2.5 m. There were two fishes captured: one Asp *Aspius aspius* Linnaeus, 1758) and one Sneep, Sneep (*Chondrostoma nasus* Linnaeus, 1758) (Figure 18).

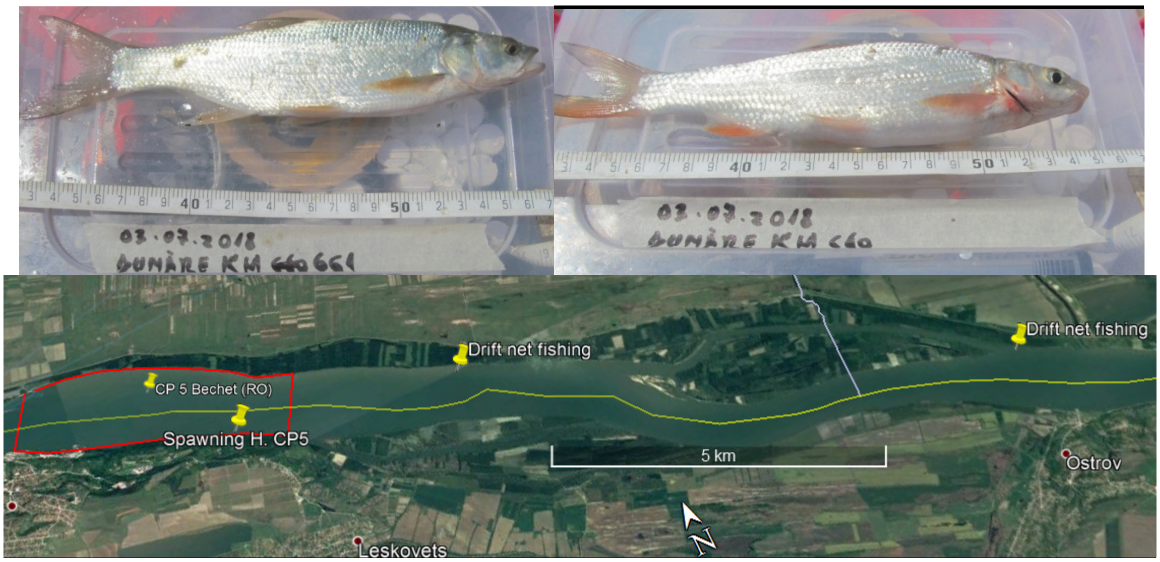


*Figure 18: Danube River km 671-670 Asp (Aspius aspius Linnaeus, 1758) / (left) Sneep (Chondrostoma nasus Linnaeus, 1758) / (right)*

During Field trip 2, a potential sturgeon spawning habitat was identified between CPs 5 and 6) at rkm 658 close to Bulgarian river bank (Figure 19). The location of the potential sturgeon spawning habitat beginning at N:$43^0$ 40.822` E:$24^0$ 11.686`and ending at N:$43^0$ 40.962` E:$24^0$ 11.985`. In this location, the bottom samples extracted revealed gravel substrate and larger soft stones similar to those found in 2012 on Borcea Branch (Figure 19).


*Figure 19: Danube River km 658, potential spawning habitat located close to Bulgarian Danube River bank*

The river sector located between CP 5 (Bechet) and CP 6 (Corabia) has rocky banks on Bulgarian river side that may create good areas for surgeon spawning. Potential sturgeon spawning habitat was located close to Gorni Vidin (BG) locality (Figure 20). Location of the potential sturgeons spawning habitat beginning: N: $43^0$ 41.067` E:$24^0$ 13.695`, middle: N:$43^0$ 41.130` E:$24^0$ 13.901`, end: N:$43^0$ 41.228` E:$24^0$ 14.184`

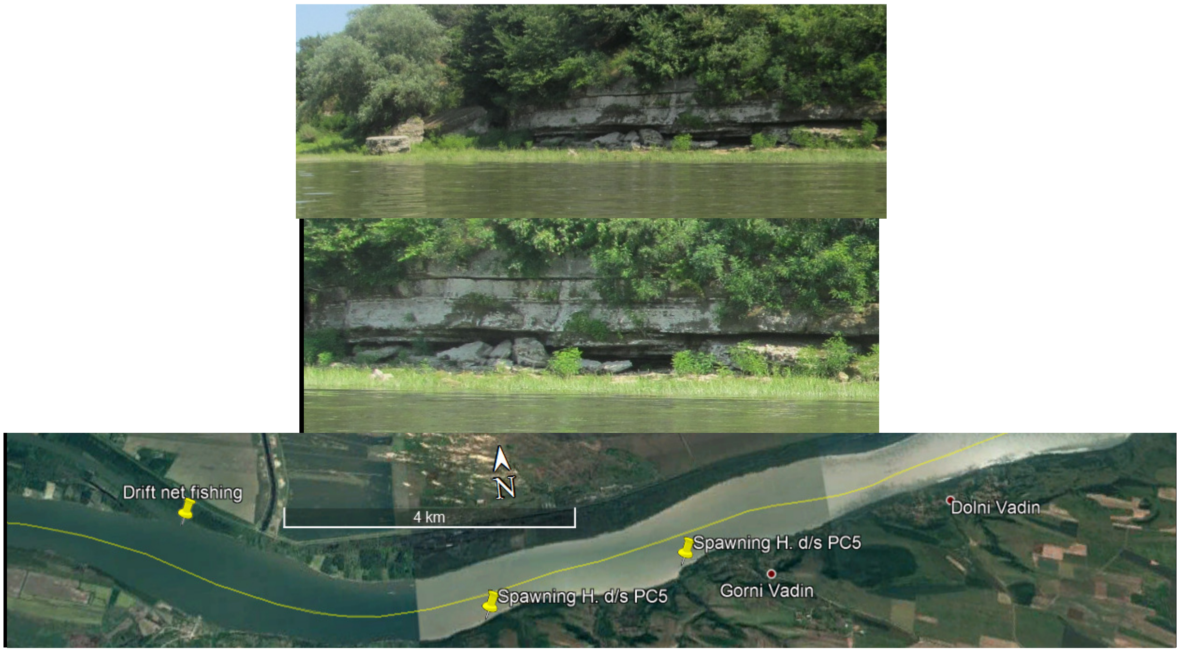


*Figure 20: Danube River km 656, potential spawning habitat located close to Gorni Vidin (BG) locality*

A potential sturgeon spawning habitat was located close to Dolini Vidin (BG) locality. Location of the potential sturgeons spawning habitat beginning: N:$43^0$ 41.447` E:$24^0$ 15.746`, end: N:$43^0$ 41.455` E:$24^0$ 15.950` (Figure 21).

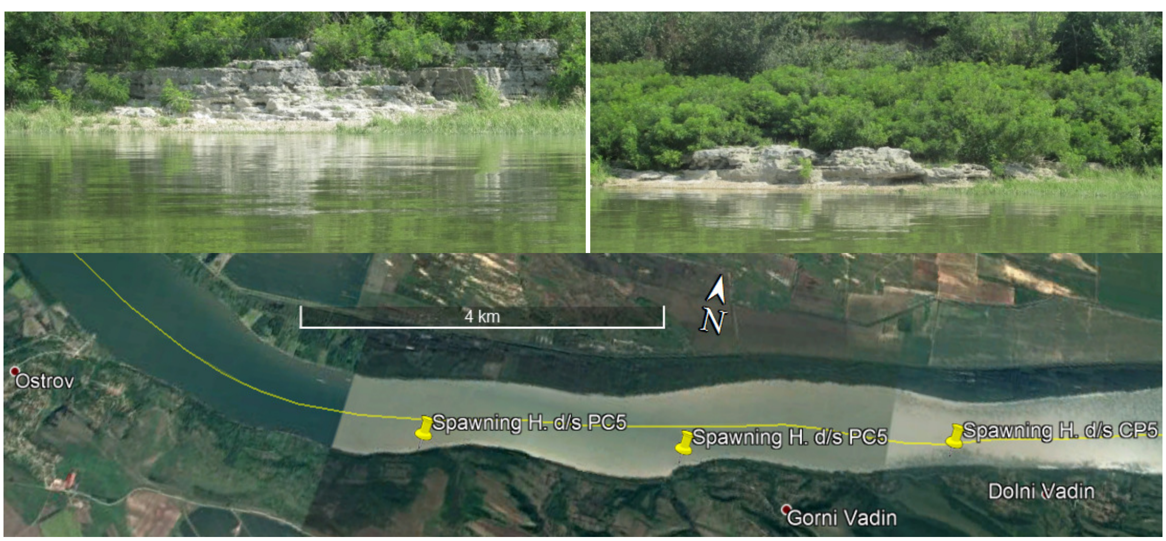


*Figure 21: Danube River km 653, potential spawning habitat located close to Dolini Vidin (BG) locality*

Upstream of CP 6 (Corabia) further potential sturgeon spawning habitat was identified

Location of the potential sturgeons spawning habitat beginning: N:$43^0$ 42.134` E:$24^0$ 21.918` end: N:$43^0$ 42.262` E:$24^0$ 21.918` (Figure 22).

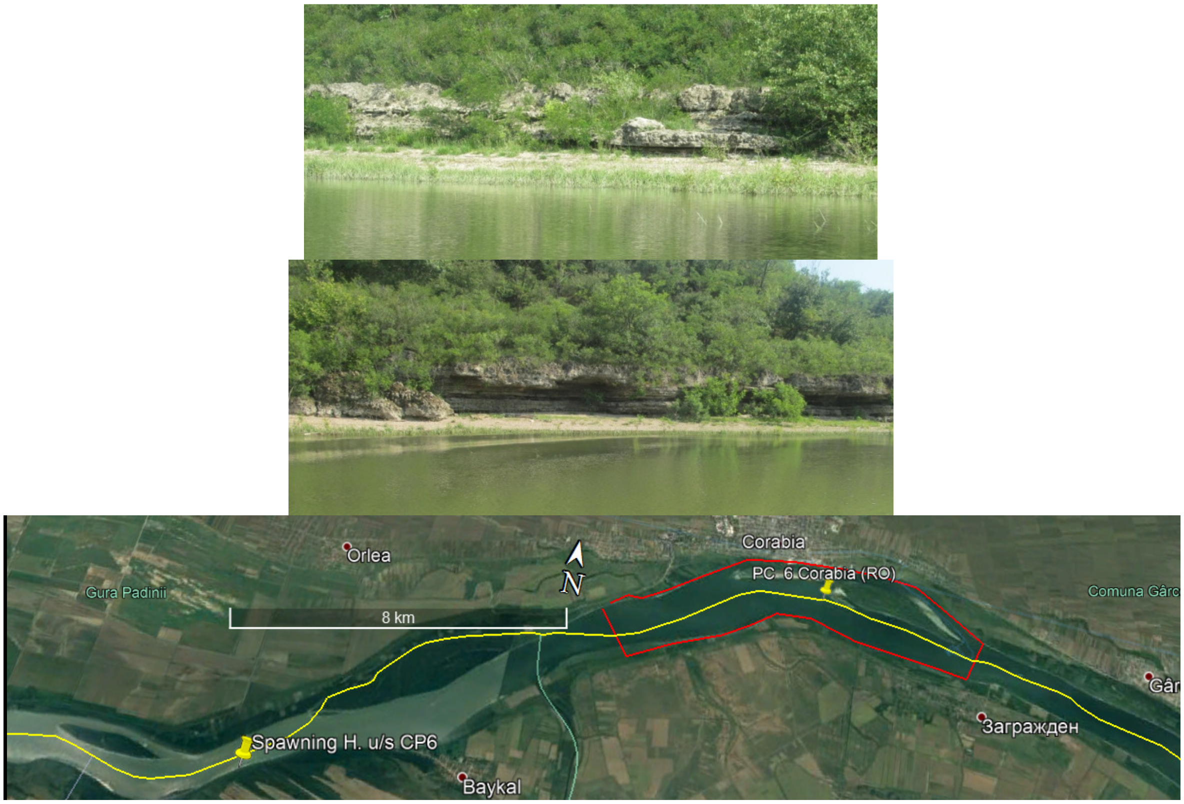


Figure 22: Potential spawning habitat located close to Bulgarian Danube River bank

The potential spawning area continues up to rkm 643 where on the Bulgarian river bank areas of gravel can be observed (Figure 23). Location of the potential sturgeons spawning habitat: N:$43^0$ 42.396` E:$24^0$ 22.598`.


Figure 23: Dnube River km 644-643, potential spawning habitat located close to Bulgarian Danube River bank

### Critical Point 6 Corabia – Romanian sector

In the CP 6 (Corabia), between rkm623 -622 there are vertical clay banks, similar to the vertical clay banks on the Borcea branch. These banks may be used as spawning location by the Stellate Sturgeons (Figure 24). Location of the potential sturgeons spawning habitat: N: 43° 46.281', E: 24° 32.446'.


*Figure 24: 15: Vertical clay banks potential spawning habitats used by Stellate Sturgeons at CP 6*

During Field Trip 2, the downstream limit of CP 6, at rkm 626 was investigated as a potential feeding / nursery ground for YOY sturgeons close to the tail of the island (Figure 26). Before fishing a bottom sample was taken, this revealed the presence of the small worms in the muddy substrate (Figure 25) similar to those found in the confirmed feeding habitat from rkm 123. Location of the potential feeding / nursery habitat: N:43$^0$ 45.566\` E:24$^0$ 33.546\` /18:20.


*Figure 25: Bottom samples with worms extracted with Van Veen grab sampler at rkm 626*

After the experimental fishing in the potential YOY sturgeon feeding habitat there were three Pontic Shad captured (Figure 26) revealing their presence in the area.


*Figure 26: Pontic Shad (Alosa immaculata) captured at rkm 626 CP 6 (Corabia)*

The drift net was launched twice downstream of CP 6 in the location: N:43$^0$ 42.880\` E:24$^0$ 41.175\` where water depth was 4.2 m, and N:43$^0$ 42.797\` E:24$^0$ 48.280\` where water depth was 4 m where no fish was captured.

On the Bulgarian river bank between N:43°42.690' E: 24° 49.416' and N:43$^0$ 42.757\` E:24$^0$ 49.803\` potential sturgeon spawning habitat was investigated. The bottom sample revealed a sandy substrate, not common for the Beluga Sturgeon spawning areas (Figure 27).


*Figure 27: Potential sturgeon spawning habitat investigated at rkm 604 Bulgarian river bank*

Potential spawning sturgeon habitat located between CP 6 (Corabia) and CP 7 (Belene) close to Nikopol (BG). Location of the potential sturgeons spawning habitat beginning N: 43° 42.610' E:24° 54.725' end N: 43° 42.782'N 24° 55.929'E. The bottom sample collected revealed gravel substrate (Figure 28).


*Figure 28: Potential sturgeon spawning habitat investigated at Danube River km 595 / Bulgarian River bank*

Potential wintering sturgeon wintering habitat was investigated on a small branch upstream of CP 7 (Belene). Location of the potential sturgeons wintering habitat N: 430 43.625` E:$25^0$ 01.400` (Figure 29)

### Critical Point 7 Belene – Bulgarian sector

Approximately 1km upstream of CP 7 (Belene) a potential sturgeon spawning habitat was investigated, at rkm 576 close to Bulgarian river bank (Figure 29). Location of the potential sturgeons spawning habitat: N:43$^0$ 41.161` E:25$^0$ 05.130`. The bottom sample revealed gravel substrate specific to Beluga Sturgeon spawning habitat (Figure 29).

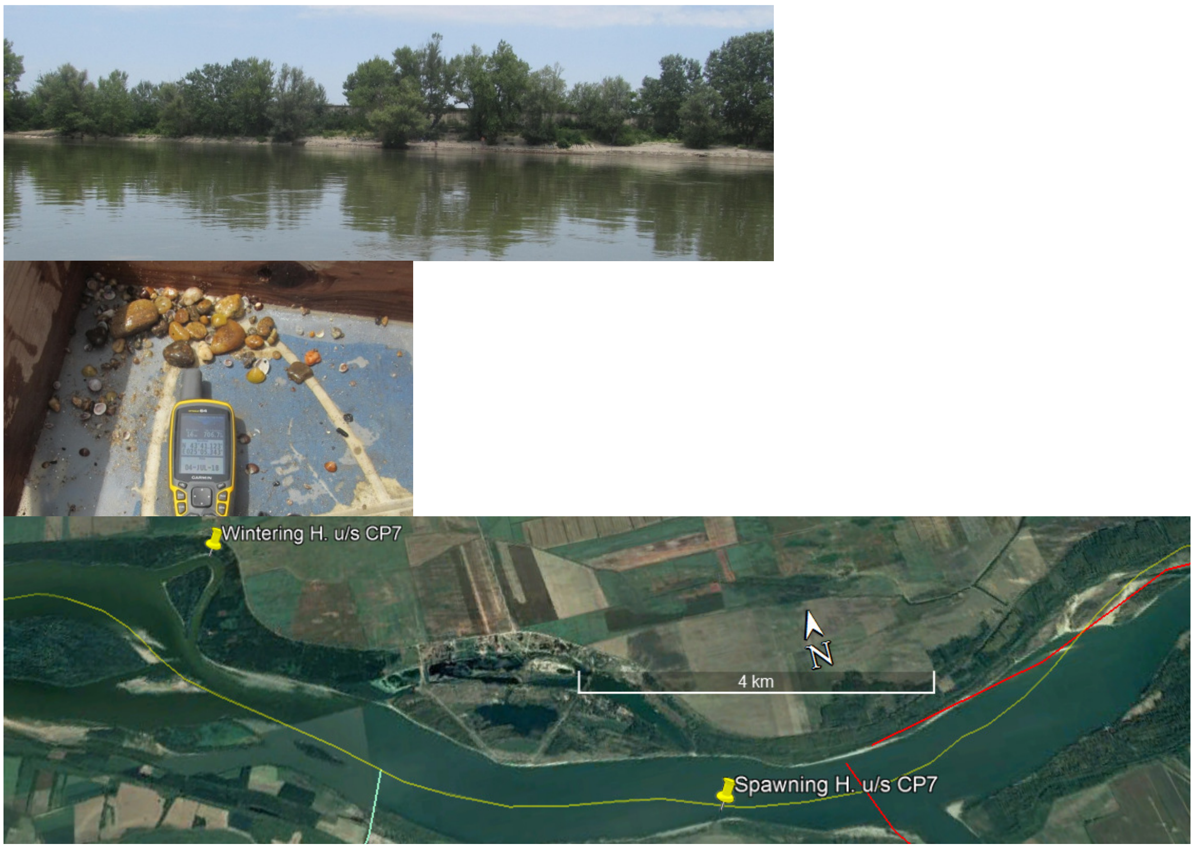


*Figure 29: Potential sturgeon spawning habitat and wintering habitat investigated upstream CP 7 (Belene)*

Within CP 7 (Belene) a potential YOY feeding / nursery habitat is located at rkm 571, at the tail of the island formed close to Romanian river bank. Location of the potential sturgeons feeding habitat: N:43$^0$ 42.036` E:25$^0$ 09.901`. The bottom sample revealed worms in the muddy substrate, specific to this kind of habitat (Figure 30).

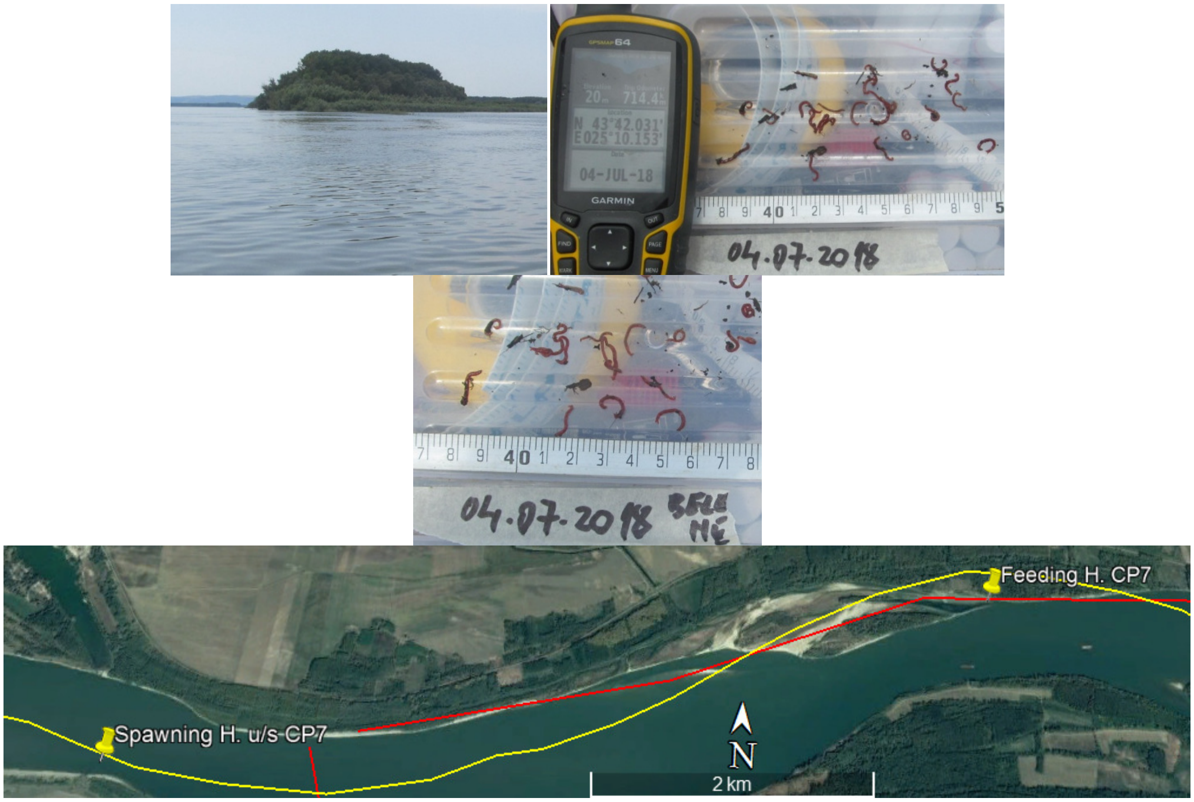

Figure 30: Potential feeding ground downstream the island / worms

On the Romanian river bank within CP 7 area there are vertical clay banks at rkm 570 to 569 (GPS location - N:43° 41.869' E:25° 11.921') (Figure 31) and at rkm 566 to 565 (GPS location – N:43° 41.384' E: 25° 14.358') (Figure 32). These vertical clay banks are similar to those on the Borcea branch and may be used by Stellate sturgeon for spawning during the high Danube River water period of April – May.

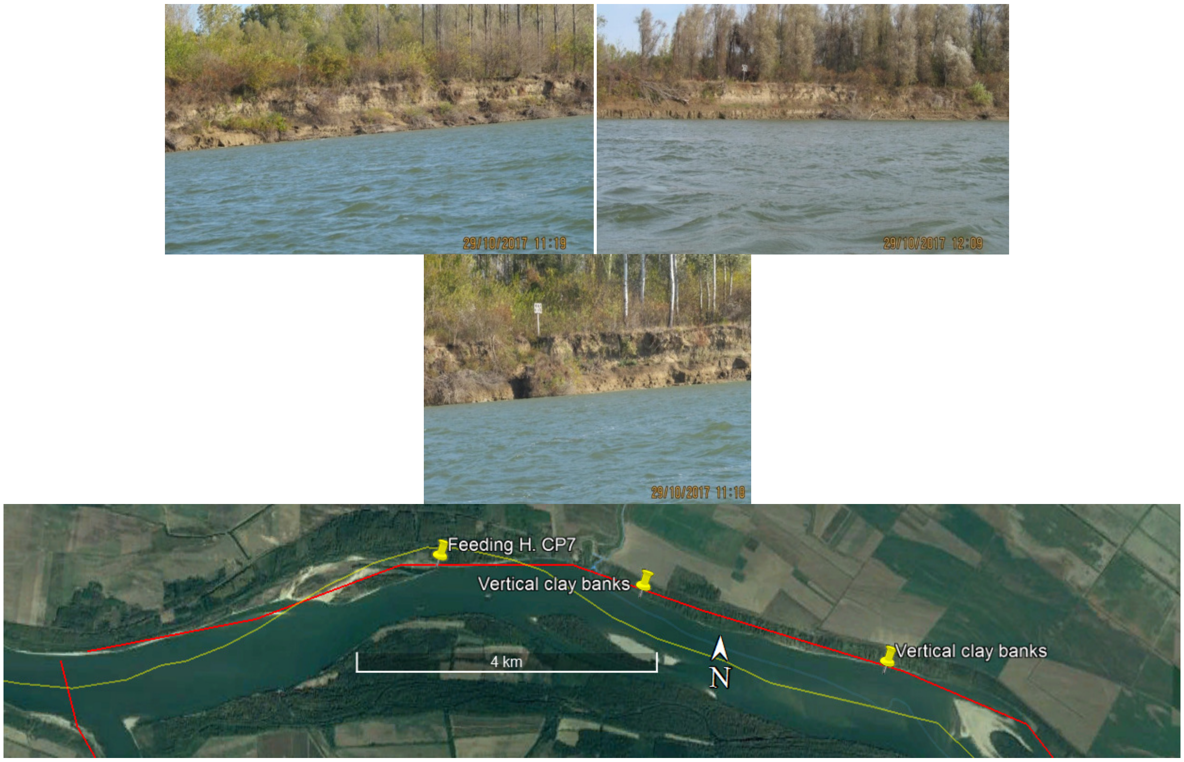


*Figure 31: Vertical clay banks potential spawning habitats used by Stellate Sturgeons CP 7*

*Figure 32: Vertical clay banks located between rkm 565-566 in the CP 7 area*

### Critical Point 10 Batin

During the desk study and Field Trip 1, a potential wintering habitat was located in the area of CP 10 (Batin). The GPS location of the potential sturgeon wintering habitat: N $43^{0}$41.804` E $025^{0}$42.581` (Figure 33).


*Figure 33: 18: Potential sturgeon wintering downstream Batin - CP 10*

### Critical Point 11 Kosui – BG sector

During Field Trip 2, experimental fishing was performed in CP 11 (Kosui) at rkm 421 (GPS location - N:$44^{0}$ 04.761` E:$26^{0}$ 45.165` / water depth 3.4 m) and approximately 9 km downstream of the CP at rkm 414 (GPS location - N:440 06.763` E:260 50.000` / water depth 8 m) (Figure 34). No fish species was captured.

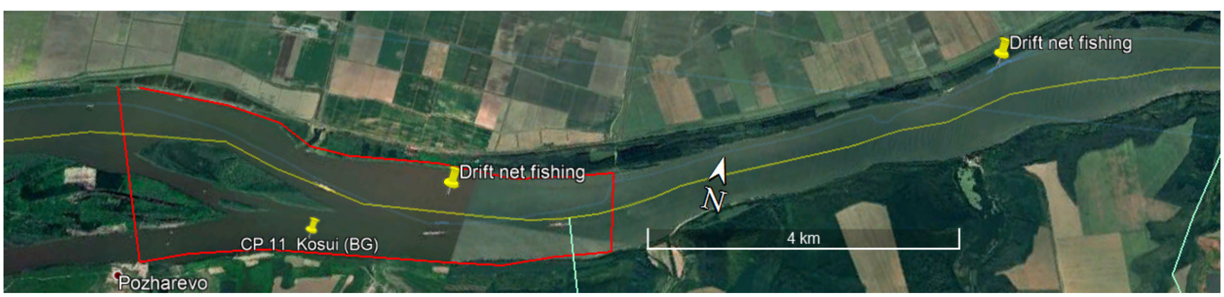


*Figure 34: Experimental fishing in the CP 11 (Kosui) area and downstream*

## Critical Point 12 Popina – BG sector

During the desk study, a potential wintering site was identified upstream of CP 12 measured the water velocities were taken in the potential wintering site located close Romanian river bank at the tail of the island (GPS location - N:440 07.546` E:260 52.644`) (Figure 35). The water velocities measured (Table 3) in the potential wintering habitat are under the critical burst swimming speed measured in sturgeon species. This potential wintering habitat may be studied during the winter time in the future project using acoustic telemetry equipment to track sturgeon movement and DIDSON camera to see whether or not this wintering habitat is used by sturgeon species for overwintering in Danube River.

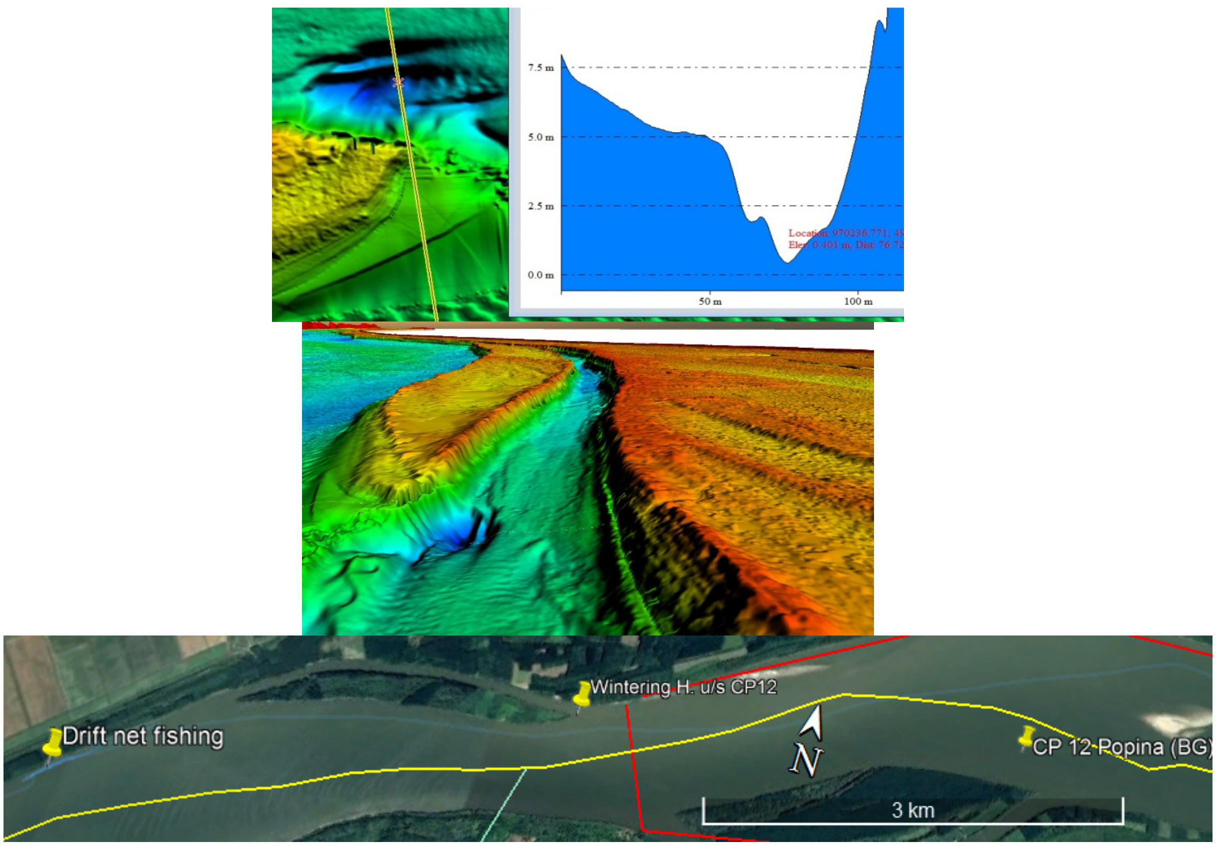


*Figure 35: Potential wintering habitat upstream CP 12 (Popina), (Marine Research Team bathymetry images)*

*Table 3: Water velocities measurements in the potential wintering site located upstream CP 12*

| Nr. Crt. | Potential habitat | Coordinate | 20 cm from water surface [m/s] | 50 cm from water surface [m/s] | 100 cm from water surface [m/s] | 100 cm from water surface [m/s] | 200 cm from water surface [m/s] | 400 cm from water surface [m/s] |
|---|---|---|---|---|---|---|---|---|
| 1 | | N:44⁰ 07.546` E:26⁰ 52.644` | 0.19 | 0.36 | 0.4 | 0.32 | 0.35 | 0.34 |
| 2 | Iernare | | 0.16 | 0.36 | 0.22 | 0.16 | 0.21 | 0.45 |
| 3 | | | 0.19 | 0.29 | 0.2 | 0.48 | 0.49 | 0.51 |
| 4 | | | | | 0.09 | 0.49 | | 0.36 |

Experimental fishing was performed just upstream of CP 12 when the drift net was launched at rkm 409, downstream of the island formed by the Danube River close to Romanian river bank in the vicinity of the potential wintering habitat (Figure 37). The fishing was performed between: N: $44^0$ 07.509` E:$26^0$ 52.782`, and: N:$44^0$ 07.686` E:$26^0$ 53.366`. Two Pontic Shad (*Alosa immaculata*) were captured (Figure 36). Two bottom samples were taken, these extracted used Van Veen grab reveal a sandy bottom substrate.

*Figure 36: Pontic Shad (Alosa immaculata) captured at rkm 409*

More experimental fishing was performed in CP 12 area close to Romanian river bank. The drift net was launched between N:$44^0$ 08.317` E:260 57.351` and N:$44^0$ 08.455` E:260 58.487` at a water depth of 4.7 meters (Figure 37). One Pontic Shad (*Alosa immaculata*), one Common bream (*Abramis brama*) and two Asp (*Aspius aspius*) (Figure 37) were captured.

Desk study and Field Trip 1 identified potential sturgeon spawning habitat between CP 11 and 12 close to Romanian river bank, rkm414 – 413. The potential spawning site starts at 44° 6.748' N / 26° 50.007' E and ends 44° 7.028' N / 26° 50.486' E (Figure 38)

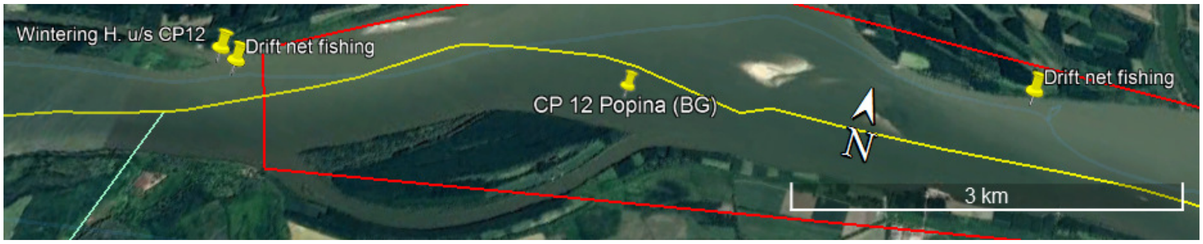


*Figure 37: Captured fish during the experimental fishing in the CP 12 (Popina) area and upstream*

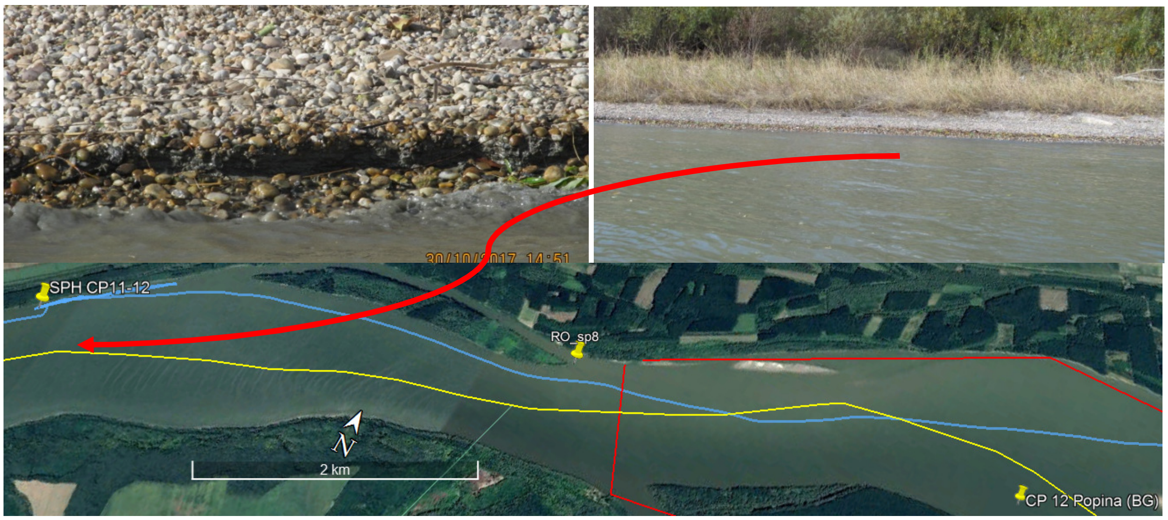


*Figure 38: River banks with gravel potential spawning habitat of Beluga Sturgeons located between CP 11 (Kosui) and CP 12 (Popina)*

# Review of proposed technical solutions for navigation and consideration of sturgeons habitats

## General categorization of modelled options

The initial simulations modelling of options was run for steady state hydrodynamic conditions at three representative flows – ENR river flows (i.e. Q94% flows), 5000 $m^3/s$ (typical flow condition) and 8000 $m^3/s$ (estimated dominant discharge for channel morphology) (report no: HRO/031/R/20180615 Jun'18). The following general options tested can be categorized as:

- "Baseline" River channel as surveyed in the first measurement campaign with no intervention.
- "Dredge only" As baseline but with present fairway alignment dredged where required achieving minimum depth of 3.0m below ENR ("maintenance dredge").
- "FS OA" As baseline but with "Optimised Alternative" solution from 2011 Feasibility Study implemented – training structures plus dredging as required: 3.0m minimum depth on present fairway alignment ("maintenance dredge"); 3.5m minimum depth on any fairway realignment ("capital dredge").
- "Structures" As baseline but with an alternative solution implemented comprising training structures plus dredging as required: 3.0m minimum depth on present fairway alignment ("maintenance dredge"); 3.5 m minimum depth on any fairway realignment ("capital dredge").
- "Islands" As baseline but with an alternative solution implemented comprising artificial islands (combined with training structures in some cases) plus dredging as required: 3.0m minimum depth on present fairway alignment ("maintenance dredge"); 3.5m minimum depth on any fairway realignment ("capital dredge") (report no: HRO/031/R/20180615 Jun'18).

The model results provided first assessment of the relative performance of the different types of solution and the impacts which was considered for selecting the preferred type of solution (report no: HRO/031/R/20180615 Jun'18).

## Critical Point 3 Bogdan Secian / RO sector

Potential options for improving navigation in CP3, Bogdan Secian of the Danube River according the report number: HRO/031/R/20180615 Jun'18 /pp. 42 - 45

1. Baseline option
2. Dredge only option
3. Bed raise option
4. Island option
5. FS OA Chevron option

**Recommended solution regarding the sturgeons habitats:** Option No. 4 - Island option

Justification for the recommended technical solution regarding sturgeon habitats:

Islands provide favorable habitat for Sturgeons, however they are known to avoid sites with structures producing in the water non - natural noises. Provision of an island at CP3 will increase in velocities in some parts of the navigation channel at all three considered flows, with maximum velocities reaching up to 1.4 m/s, and there would be a significant increase in velocities west of the head of the island at Q5000 and Q8000 flows, with maximum velocities reaching up to 2 m/s (report: HRO/031/R/20180615).

Island seems to be good solution because it can be designed to be as natural as possible and to produce less noise, while Chevrons are not recommended as they introduce high non - natural noises and flow velocities.

Provision of the island is affecting less the access to the migration corridor along the right bank, towards potential hard substrate habitats along the Bulgarian bank.

A solution which requires bed raising will affect the bottom of the river between the Bulgarian river bank and the existing natural island. The Pontic shad a pelagic migratory fish species may not be affected by this solution but sturgeons, for whom the majority of their migratory journey is done following the bottom of the river, will be adversely affected by this solution.

## Critical Point 5 Bechet / RO sector

Potential options for improving navigation in CP 5 of the Danube River according the report number: HRO/031/R/20180615 Jun'18 / pp. 50-53

1. Baseline option
2. Dredge only option
3. Chevrons and dikes with fairway realignment option
4. Islands with fairway realignment option
5. FS OA dikes and chevron with fairway realignment:

**Recommended solution regarding the sturgeon habitats:** Option No. 4 - Island with fairway realignment option

Justification for the recommended technical solution regarding sturgeon habitats.

Although the island solution with fairway realignment option would result in increase in velocities in some parts of the proposed realigned channel at all three flows, with maximum velocities reaching up to 2 m/s and a significant increase in velocities north of the head of the upstream island at all three flows, with velocities exceeding 2 m/s (report HRO/031/R/20180615) it seems that the island will be a better solution because it does not affect the Bulgarian river bank.

Islands provide favourable habitat for Sturgeons whilst they avoid sites with structures producing in the water non - natural noises. Solution Island with fairway realignment solution because it can be designed to be as natural as possible and to produce less noise, while the chevrons are not recommended as they introduce non-natural noises in the river habitats. In addition, the island solution offers the opportunity to shape and create during their construction, artificial feeding and wintering habitats suited for surgeons to see whether the river accept / maintain them and whether or not the sturgeons will use them. This possibility of testing different solutions will improve the knowledge about migratory fish species that will be very useful for future projects to be carried out on the Danube River.

The potential options to provide chevrons and dikes with fairway realignment option will change drastically the Bulgarian river bank increasing the deposition of sediment in the area where the configuration of the riverbank suggests the existence of a sturgeon spawning habitat; it should therefore be avoided (see Figure 17).

## Critical Point 6 Corabia / RO sector

Proposed solution for improving navigation in this sector of the Danube River according the report number: HRO/031/R/20180615 Jun’18 / pp. 54 - 57

1. Baseline option
2. Dredge only option
3. Dikes option
4. Dike and island option
5. FS OA dike and chevrons with fairway realignment:

**Recommended solution regarding the sturgeons habitats:** Dike and island option

Justification for the recommended technical solution regarding sturgeon habitats

The dike and island option would result in increase in velocities in some parts of the navigation channel at Q94% and Q5000 flows, with maximum velocities reaching up to 1.4m/s. The dike and island option would not lead to a significant increase in local water levels at the three considered flows (report HRO/031/R/20180615).

Solution Island avoids affecting accessibility of sturgeons to the hard substrates / potential spawning grounds along the right bank. Solution Dikes would induce the most artificial noise in the river and disturb overall migration of sturgeons towards upstream. Solution Chevrons & Dikes is affecting exactly the potential spawning grounds with hard substrate. Water flow (1.4 - 1.6 m/s) induced at high discharge (8000 m3 /s) is still within limits accessible for all sturgeon species.

## Critical Point 7 Belene / BG sector

Proposed solution for improving navigation in this sector of the Danube River according the report number: HRO/031/R/20180615 Jun'18 /pp. 58 - 61

1. Baseline option
2. Dredge only option
3. Chevrons and dikes with fairway realignment option
4. Islands with fairway realignment option
5. FS OA dikes with fairway realignment:

**Recommended solution regarding the sturgeons habitats:** Dredge only option; or Islands with fairway realignment option

Justification for the recommended technical solution regarding sturgeon habitats

One of the two recommended technical solutions is dredge only which should be done avoiding the period of the year when the sturgeon are spawning (April – June). The frequency of maintenance dredging and the location for the dumping / depositing of the material dredged form the river need to be confirmed.

The islands with fairway realignment is more complex solution which can also may have a small impact over the potential habitats used by sturgeons in CP 7 (Belene) although there would result in increase in velocities in some parts of the proposed realigned channel at all three flows, with maximum velocities exceeding 2m/s according the HRO/031/R/20180615 report.

Islands provide favorable habitat for sturgeons, however they are known to avoid sites with structures producing in the water non - natural noises. Solution Island with fairway realignment seems to best meet these constraints, as the chevron option introduces non natural noises in the river habitats.

## Critical Point 12 Popina / BG sector

Proposed Solution for improving navigation in this sector of the Danube River according the report number: HRO/031/R/20180615 Jun'18 / pp. 77- 80

1. Baseline option
2. Dredge only option
3. Dikes with fairway realignment option
4. Island with fairway realignment option
5. FS OA dikes with fairway realignment

**Recommended solution regarding the sturgeon habitats:** Island with fairway realignment option

Justification for the recommended technical solution regarding sturgeon habitats:

The island with fairway realignment option would result in increase in velocities in some parts of the proposed realigned channel at all three flows, with maximum velocities reaching up to 2m/s. In addition, there would also be a more significant increase in velocities south of the head of the island at Q5000 and Q8000 flows, with velocities reaching up to 2 m/s at Q5000 flow, and exceeding 2 m/s at Q8000 flow. A water velocity greater than 2.5 m/s may cause difficulties in upstream swimming sturgeon migration (Webber 2007). There would also be some minor local decreases in the velocities at the downstream end of the proposed island (report: HRO/031/R/20180615).

Even if there will be an increase in velocities in some parts of the proposed realigned channel at all three flows, the island solution is the most environmental friendly solution regarding the fish migratory species.

Solution island with fairway realignment option seems to be the most sturgeon migration friendly, inducing the less artificial noise compared to the rest of solution because it will be a permanent solution that will require less intervention in the river after they were constructed. The island may be constructed in such way to be as natural as possible and in the downstream part of the island the river may also create over the time sediment deposits specific for YOY feeding ground.

## Conclusions

The work with migratory fish and other living species involves studying them during the periods in which they live in the Danube River. We know that a tagged beluga sturgeon return in the river after 2, 3 up to 5 year (Otel 2007) for spawning again, moment when you will be able to collect data about their migration. Due to the scale of the project and the fact that following preliminary modelling works the likelihood was that interventions over and above dredge only would only be at four CPS we focused our attention on the following four critical areas: CP 5 (Bechet), CP 6 (Corabia), CP 7 (Belene) and CP 12 (Popina).

The field work undertaken todate has clearly shows that there are more vertical clay banks on the Romanian river side compared to the Bulgarian river side. The vertical clay banks identified during the field work are considered to be similar to those on the Borcea branch where, in 2012 captured adult male Stellate Sturgeons were found to be releasing semen during the handling.

Vertical clay river banks are therefore known to be used by Stellate Sturgeon for spawning. Field surveys undertaken have found that on the Bulgarian river side there are more rocky banks. These rocky banks are considered to be similar to the banks at rkm 310 (Figure 8) and rkm 100 where were there have been previous confirmations of Beluga Sturgeon and Sterlet Sturgeon larvae after the spawning period.

Sturgeons are known as poor swimmers 1.4 – 1.6 m/s is the so called critical burst swimming speed for the North American White Sturgeon - this parameter for the four species of sturgeons which migrate in the LDR is unknown. Swimming speed of sturgeons is species and size / age related. Large / old Beluga sturgeons have been recorded by the INCDD swimming a distance of 746km upstream over 19-day period. This equates to a ground cruise speed of only 0.51 m/s.

Despite the uncertainty regards the critical burst swimming speed for Danube species is it considered that to be on the safe side for not disrupting sturgeon migration and to provide the most favourable conditions for other fishes migrating in the LDR **average water velocities induced by hydro-technical works should not surpass 1.6 m/s.**

Migrating sturgeon migrating upstream always swim very close to the bottom (in the first 0.5 m of the water column) and they use the "shoulder" of the channel. In the LDR they never use water depth of less than 2.5 – 3 m. By dredging the fairway, the navigation project may provide a sturgeon's migration channel that is over 2.5 m deep. The dredging only should be done avoiding the period of the year when the sturgeon is spawning (April - June), further information is required on the necessary occurrence of maintenance dredging. The dumping / depositing of the dredged material collected from the river should be undertaken in such way to avoid affecting the fish fauna habitats.

The hard structures that contain rocks, concrete, and other materials that don't originate from the river is less sturgeon migration friendly solution. Usually the artificial constructions like chevrons and dikes induce the most artificial noise in the river and disturb overall migration of sturgeons towards upstream islands which may produce less artificial noise are likely affect access to the migration corridor less.

Islands provide favourable habitat for sturgeons whilst they avoid sites with structures producing in the water non - natural noises. In general Solution Island seems to be a better solution because it offers the possibility of using a more environmentally friendly structure that can be shaped in the way to be integrated in the area where it is built, while the solution like chevrons is inducing non-natural noises in the river habitats. In addition, the island solution offers the opportunity to shape and create during their construction, artificial feeding and wintering habitats suited for surgeons to see whether the river accept / maintain them and whether or not the sturgeons will use them. This possibility of testing different solution will improve the knowledge about migratory fish species that will be very useful for future projects to be carried out on the Danube River.

There are only four remaining species of wild sturgeon in the European Union; these are located within the LDR. Much attention needs to be given to the fact that there is currently little known about the spawning habitats of these fishes. It is important that as much as possible, the FAST Danube project avoids disturbance of all functional sites, and, if possible, includes design and reconstruction nearby, in the new fair way, of the new sites that may be used by migratory fish.

Other important migratory fish species in the LDR are the Danube Shads, these are poorly studied species consisting of possibly three or four distinct species / subspecies migrating at distinct time in the Danube, all reaching the Iron Gate II dams. There is no swimming speed measurement for the LDR shads but recent measurements in the larger and stronger Twite shad (*Alosa fallax*) have recorded a critical burst swimming speed limit of approximately 2.5 m/s and cruise speeds (or so called maximum sustainable swimming seed - MSSS) of 0.51 m/s. The Pontic shad (*Alosa immaculata*) and Azov Shad (*Alosa tanaica*) are species that spawn in the water column, the eggs are pelagic, and larvae drift passively to the Black Sea (Aprahamian 2003; Navodaru 1998). Due to this spawning behavior the Pontic shad and Azov Shad are less affected than sturgeon species that spawn on hard substrate which will be affected by planned works on changing the navigation channel in order to improve the navigation.

The survey of Pontic shad and Azov Shad was limited to identify their presence or absence in the area. During the surveys Pontic Shad was captured at rkm 661 (Figure 18), rkm 626 (Figure 26) rkm 401 (Figure 37), rkm 409 (Figure 36). Although shad species are very sensitive (shad died soon after is captured) telemetry studies may be attempted to try to collect more data about shad migration behaviour, and also assessment of Shad stocks in the Danube River by control fishing.

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