

Fish migration at the Iron Gate dams

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Introduction

The Iron Gates I and II Dams on the border of Romania and Serbia are the first barriers for sturgeon and other migratory fish species along the Danube River from the Black Sea. The dam complexes consist of weirs, spillways, ship locks and hydropower stations. The Iron Gates are located at ca. 850 km distance from the delta in the Black Sea. Restoration of river continuity at these sites would re-open a reach of more than 800 km upstream to the Gabčíkovo Dam, downstream of Bratislava on the border of Slovakia and Hungary. This will provide habitat and spawning grounds along the main river and its tributaries to numerous Danube migratory fish species.

The European Water Framework Directive (WFD) implementation is legally binding for EU Member States, however Non EU Member States also politically committed themselves to implement the WFD in the Danube Basin. Therefore, Danube River Basin (DRB) countries are committed to reach a good ecological status for the Danube River. One aspect of this is to ensure self-sustaining fish populations. This includes the restoration of the longitudinal connectivity of the river which is necessary for migratory fish to reach spawning, feeding and nursery areas (Comoglio, 2011). In the Sturgeon Action Plan (Bloesch et al., 2005) and the Danube River Basin Management Plan (ICDPR, 2009), reopening the fish migration routes at the Iron Gate dams I and II and the Gabčíkovo dam is classified as 'outmost priority' (see also figure 1).

In 2011 the FAO undertook a scoping mission as a first preliminary assessment of general possibilities for fish migration solutions at the Iron Gate dams (Comoglio, 2011). The present paper is the result of a project carried out subsequent to the FAO scoping mission and further develops some of the most promising fish migration solutions. (Full report: de Bruijne et al., 2014).

Background

The Danube River with a length of 2,872 km is the second largest river on the European continent after the Volga River in Russia. It originates in the Black Forest in Germany and flows through or passes the borders of Austria, Slovakia, Hungary, Croatia, Serbia, Bulgaria, Romania, Moldova and Ukraine before entering the Black Sea (figure 1). The Danube's tributaries flow through nine more countries, the total catchment area measures 817,000 km² (Sommerwerk et al., 2009).



Figure 1: Ecological prioritization regarding restoration measures for river continuity (ICPDR, 2009)

Fish migration in the Danube

All fish species in a river system migrate to some extent between spawning, nursery, feeding and overwintering habitats. Some fish movements take place on a daily basis, for example to feeding areas, while reproduction migration only takes place once a year or even once in a lifetime. Also the distance covered varies for different types of migration and also among species. Headwater species migrate for comparatively short distances in a small time frame while the lowland waters host long distance migrants such as sturgeon species which migrate several thousands of kilometres from the Black Sea up to the barbel zone (Schmutz & Trautwein, 2009). These species even show a phased migration with an overwintering period in between. Therefore the migratory requirements of Danube fish species are more distinct in the lowland fish communities than in the headwater fish communities (Schmutz & Trautwein, 2009). Most present species like nase (*Chondrostoma nasus*), barbel (*Barbus barbus*) and bream (*Abramis brama*) migrate within certain river sections and tributaries over distances of tens to several hundreds of kilometres. However, in the end all species are dependent on open migration routes in a river system to maintain sustainable and healthy fish communities.

All species show migratory behaviour but most species are categorized as resident species because they only depict local migration behaviour. Subsequently one can distinguish medium distance migrants and long distant migrants. The latter are typically the flagship species of a river due to their size, cultural and economic importance and presence in a large part of the basin. For the

Danube River typical long distance migrants are the four large sturgeon species and two of the present shad species, while among the medium distance migrants is the fifth Danube sturgeon species, the sterlet (table 1).

Table 1: Long and medium distance migrants in the Danube River (adapted from Schmutz & Trautwein, 2009)

Long distance migrants	Medium distance migrants
<i>Acipenser gueldenstaedti</i> (Danube/ Russian sturgeon)	<i>Abramis brama</i> (common bream)
<i>Acipenser nudiiventris</i> (ship sturgeon) – possibly extinct in the Danube River	<i>Abramis sapa</i> (danubian bream)
<i>Acipenser stellatus</i> (stellate or starred sturgeon)	<i>Acipenser ruthenus</i> (Sterlet)
<i>Acipenser sturio</i> (common or Atlantic sturgeon) - extinct in the Danube River	<i>Aspius aspius</i> (asp)
<i>Huso huso</i> (beluga or great sturgeon)	<i>Barbus barbus</i> (barbel)
<i>Alosa caspia</i> (caspiian shad)	<i>Chondrostoma nasus</i> (nase)
<i>Alosa immaculate</i> (pontic shad)	<i>Hucho hucho</i> (danube salmon)
	<i>Lota lota</i> (burbot)
	<i>Vimba vimba</i> (vimba)

The Sturgeon Action Plan (Bloesch et al., 2005) indicates that recent observations in the lower Danube River show that all sturgeon populations are near to extinction. Five of the six species are classified as ‘Endangered’, ‘Critically Endangered’ or ‘Vulnerable’ according to the *2004 IUCN Red List of Threatened Species*. Their long migration routes make them particularly sensitive to the impacts of physical obstructions. Four of the Danube species live mainly in the shelf zone of the Black Sea, only entering the Danube system for spawning: *Acipenser gueldenstaedti*, *Acipenser stellatus*, *Acipenser sturio* and *Huso huso* (Bloesch et al., 2005). *Acipenser ruthenus*, the Danube form of *Acipenser nudiiventris* and a resident form of *Acipenser gueldenstaedti* migrate within the main river (Bloesch et al., 2005).

These sturgeon species are particularly vulnerable due to their long lifecycle (Reinartz, 2002). Populations take decades to recover after a disturbance. Therefore they are threatened by:

- Over exploitation;
- Habitat loss and degradation;
- Disruption of spawning migrations (dam construction);
- Pollution;
- Changes in the genetic status of the population;
- Invasive species (possible food competition);

A range of measures has been taken for sturgeon conservation but sturgeon populations are close to extinction. Therefore the Sturgeon Action Plan under the Bern Convention was prepared (Bloesch et al., 2005). The Danube sturgeons will not survive unless poaching pressure is reduced, and both migration routes and habitats for all life-cycle stages are protected and restored (Bloesch et al., 2005).

Scheme layout hydropower plants

The Iron Gates Hydroelectric and Navigation Scheme was put in place based on an agreement concluded in 1963 between Romania and Yugoslavia. Iron Gates I (located at Danube km 942) was constructed in 1972, and Iron Gates II ca. 80 km downstream in 1984 (figure 2, left).

Iron Gates II

The lower Iron Gates II scheme is composed of two dams; the lower (main) dam on the main stem of the Danube River at km 862 (1. In figure 2), and the upper dam on the Gogoşu branch at km 875 (2. In figure 2). There exist two navigation locks; one on the Southwestern side of the main dam (3. In figure 2) and another about 1.2 km north of the main dam on Ostrovul Mare Island (4. In figure 2). The main dam incorporates 14 spillways with tainter (radial) gates.



Figure 2: Location Iron Gates I and II (left) and scheme lay out of Iron Gates II (source: Google Earth).

The main hydropower plant (1. in figure 2) is situated on the north-eastern side of the main weir, or left bank respectively (figure 3). It includes 2 x 8 bulb turbines with a design flow of 425 m³/s each and 6,800 m³/s in total. The turbine diameter amounts to 7.50 m. Each turbine has 4 fixed blades. There are two other smaller hydropower plants with two sets of turbines each, one on the Gogoşu dam (2. In figure 2) and the other on the Serbian side of the main dam (3. In figure 2). The design head is 7.45 m.



Figure 3: Iron Gates II main dam downstream view (left) and Iron Gates I dam downstream view (right) (photos: Wilco de Bruijne)

Iron Gates I

The Iron Gates I dam (figure 3 right) has a total width of 1.28 km and an almost symmetrical design. This allows both countries to exploit the water resources equally for electricity production and navigation purposes. On both banks the dam is equipped with double step navigation locks which operate 14 times/day on average (Comoglio, 2011). A spillway forms the centre of the dam and is made up of 14 sections, each 25 m wide; the upper 14.5 m reservoir lamella can be regulated by hooked gates. The border of Romania and Serbia lies in the middle of the river - a road linking both countries runs on the dam crest.

There are hydropower plants on both the Romanian and Serbian river sides. These include 2 x 6 double regulated vertical Kaplan units with a capacity of 194.5 MW each. The Romanian turbines were rehabilitated recently. The design flow amounts to 840 m³/s per turbine (10,080 m³/s in total). A turbine measures 9.50 m in diameter. Each turbine has 6 variable blades and wicket gates. The maximum head amounts to 28 m.

Sturgeon monitoring

In order to gain site specific information on sturgeon migration behaviour, experts of the Sturgeon Research Group (SRG) /Danube Delta National Institute (DDNI) Tulcea performed a radiotelemetry tagging study (VEMCO) as a part of the project. A number of sturgeons was caught and tagged (figure 4). After tagging the sturgeons were detected with receivers in order to study their behaviour downstream of the Iron Gate II complex. Information gained on the migration behaviour of sturgeons through monitoring is crucial for the design of functional fish migration solutions at the Iron Gates dams.



Figure 4: Caught male beluga sturgeon (*Huso huso*) and juvenile stellate sturgeon (*Acipenser stellatus*)

Potential measures for upstream fish migration

In principle river continuity efforts require holistic approaches, i.e. assessments of all possible and feasible options to restore passage for aquatic species at barriers. All potential solutions have to be carefully evaluated from a biological, technical and economic point of view and ranked e.g. as to their feasibility, suitability for fish species concerned, and their importance for the overall migration facilitation.

In the case of Iron Gates I and II the range of restoration possibilities, and their advantages and limitations were developed by Wilco de Bruijne and Marq Redeker (see main report) and intensively discussed at a technical workshop with international experts in Bucharest. In conclusion we identified several restoration options, including

- multiple fishways at different locations at both Iron Gates I and II,
- modification of existing structures (e.g. ship locks) as a potential initial effort and “quick win” that may also contribute to close existing knowledge gaps of local fish behaviour and fish passage preference,
- staged design approach, for example by using interim and/or mobile upstream fish pass entrance dummies to identify optimum entrance locations and attraction flow conditions, and
- alternative (temporary) management solutions, e.g. trap and truck.

Due to the size of the schemes, in particular of Iron Gates II, realistically multiple upstream fish pass facilities are necessary. However we anticipate funds to be limited, and additional constraints to exist that we may not have realized to date. Therefore we have developed exemplary preference options of fish passes to restore upstream passage, and assessed downstream passage solutions, both based on available knowledge and current understanding of the schemes. One example of a preliminary design of an exemplary preference option is given in figure 5, a large vertical slot fish pass for the Iron Gates II main dam with multiple entrances and surplus attraction flow by an additional hydroelectric power plant.



Figure 5: Preliminary layout of a vertical slot fishway at Iron Gates II

Credits: Text derived from main report (de Bruijne et al, 2014); for further information please contact one of the authors. Project partners: ARCADIS Nederland BV, Wanningen Water Consult, LINKit Consult, FishFlow Innovations & DDNI Romania.

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