Towards a Healthy Danube - Fish migration at the Iron Gate dams

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Outline

1. Project objectives
2. Situation Iron Gate Dams
3. Design criteria for up- and downstream migration of sturgeon and other species
4. Acoustic telemetry study sturgeon behavior
5. Preliminary conclusions
6. Initial design for upstream passage at Iron Gates I and II
1. Project objectives

- This project is a continuation of the initial FOA scoping mission, carried out in 2011.
- The project objective is to extend the opportunities for different fish species, including sturgeon, to migrate 800 km further upstream in the Danube River system.

Activities:

- Tagging and monitoring of sturgeons in order to determine the correct location for an upstream fish way at the Iron Gates II;
- Preliminary design of fish ways at Iron Gates I and II for upstream fish migration, including a cost estimate;
- Preliminary study for downstream fish migration possibilities.

- Downstream solutions are disregarded in this presentation because of limited time.
2. Situation Iron Gates
Iron gates I
- Drobeta-Turnu Severin

Iron gates II
- Dušanovac

Main HPP and weir
- Portile de Fier II

Romanian turbines and weir
- Mihajlovac

Romanian shiplocks
- Ostrovu Mare

Serbian shiplocks and turbines
- Radojewac
- Vraća
Iron Gates Hydrology

- Multi-annual flow (1840-2006) at Gruia is 5585 m$^3$/s.
- High annual flow variation
Iron Gates I

- Head drop 20-28m
- high (daily) variation in upstream waterlevel. Tailwater constant due to Iron Gates II reservoir
- Will prove extremely challenging for pool-type pass because of upstream waterlevel fluctuations and limited space.
Iron Gates II main HPP

- Head drop 2.5-12.8 m, designed head 7.5 m
- Comparatively low annual upstream and downstream water fluctuations.
- Many space because of flood plains.
Turbines

Iron gate I turbines
- 2 x 6 double regulated vertical Kaplan units, 194.5 MW each.
- Design discharge 840 m³/s per Turbine.

Iron gate II turbines
- 2 x 8 bulb turbines in main HPP.
- 2 each in Gogosu branch and Serbian HPP.
- Design discharge 425 m³/s per Turbine
3. Design criteria: Migratory behaviour and swimming capacity

- 6 species of sturgeon, Beluga Sturgeon up to 6m.
- Very little know on Danube sturgeons, Russian studies used as reference (Volgograd river).
- Bottom dwellers, migration patterns along the shores in deep parts.
- Nocturnal behaviour.

Building code for i.e. Fishways – State building committee of the USSR (1989):

- Flow velocity characteristics for Acipenseridae:
  - $V_{\text{threshold}} = 0.15 - 0.20$ m/s
  - $V_{\text{attraction}} = 0.70 - 1.20$ m/s
  - $V_{\text{drift adults}} = 0.90 - 1.40$ m/s
  - $V_{\text{drift juveniles}} = 0.15 - 0.20$ m/s
3. Design criteria: Geometric criteria

• Fishways for sturgeons are in operation in the former U.S.S.R. and North America. Only experience with fish lifts and fish locks.
• Building code for Fishways – State building committee of the USSR (1989):
  • Head drop < 10m: Bypass channels/ pool-type fishways:
    • Width: 3.0 – 10.0 m
    • Depth: 1.0 – 2.5 m
    • Slope: 1:8 – 1:20
  • Head drop > 10m: Hydraulic or mechanical fish lifts with collection gallery:
    • Length: 60.0 m
    • Width: 6.0 m
    • Depth: 1.5 m
• Geesthacht fish way in Germany is designed (acc. DWA-M 509) to be suitable for sturgeon. Two *Acipenser baerii* (Siberian sturgeon) passed successfully (size not mentioned).
3. Design criteria: Operation time

- Fish migration calendar present migratory species (Radu Suciu - DDNI)
- ≥ 300 d/yr fishway operation time

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- Diadromous species
- Potadromous species
- Anadromous species
- Important period for upstream migration
- Important period for downstream migration of adults
- Important period for downstream migration of juveniles
- Important period for spawning in the Danube River
4. Acoustic telemetry study sturgeon behavior
First results

- One 2m young beluga male sturgeon caught. Tagged already Nov. 2013.
- Four juvenile stellate sturgeons (too small to tag).
- Beluga was released upstream of Gogosu Branch and was detected one day later at 800m downstream of the main HPP at 6.5 m depth.
- Later several detections at the mouth of the Gogosu Branch, leaving the IG II site.
- First tagged beluga sturgeon detected at the IG II site ever.
5. Preliminary conclusions for fish way design

- Limited design criteria for locks & lifts from Russia, France, USA
- State-of-the-art design criteria pool-type fishways for anadromous and potamodromous species
- Limited design criteria for pool-type fishways for Sturgeon
  - entrance location and water depth
  - passability, i.e. hydraulic & geometric criteria
  Very limited criteria as to surplus attraction flow.
- Good info on migration periods/operation time
- Recommendation for upstream passage restoration:
  Iron Gates I: fish lift (or lock)
  Iron Gates II: pool-type fishway
- Downstream passage restoration:
  IG I & II: no viable technology for this size/discharges
6. Initial design for upstream passage at Iron Gates II

Double Vertical Slot Fishway designed acc. to DWA-M 509 (adopted by EIFAAC)
- located on left bank at HPP
- clear pool length: 9 m
- clear pool width: 13.50 m
- min. water depth: 2.50 m
- 2 slots 1.20 m wide
- head drop per baffle: 0.09 m
- max. flow velocity in slot: 1.35 m/s
- fish pass design flow: 7.50 m³/s
- 3 entrances in tailwater (at turbine outflow/ turbulent zone, below turbulent zone, and in calm river bank zone) parallel to main current and connected to river/ bank bottom

Attraction flow
- provided by a SHPP (Q_{max} \sim 45 \text{ m}^3/\text{s}, P_{el} \sim 3 \text{ MW}, Output \sim 25,500 \text{ MWh})
- attraction flow: 30 - 53 \text{ m}^3/\text{s} (= 3 \times 10 - 17.5 \text{ m}^3/\text{s} per entrance depending on downstream water level)
- attraction flow velocity: 0.8 - 1.0 \text{ m/s at entrance}
Initial design for upstream passage at IGII
Initial design for upstream passage at Iron Gates I

Mechanical or hydraulic fish lift
- located on left bank next to lock in former sluice section
- overall dimensions: ~43 x 20 m
- Lift height: +30 m
- Facility includes: outlet with gate, crowding device, holding pool, 2 side pools for attraction flow separated with fine screens, lift shaft, supply pool for lift, 2 dissipation chambers for attraction flow, shute or canal to reservoir
- Hopper dimensions: ~7 x 9 m (V ~ 100 m³)

Attraction flow
- provided by pipes from upstream
- Turbined attraction flow
- attraction flow velocity: 0.8 m/s at entrance (may be variable depending migration times of on target species)
Initial design for upstream passage at Iron Gates I
Imagine the result

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